ASTRONOMY

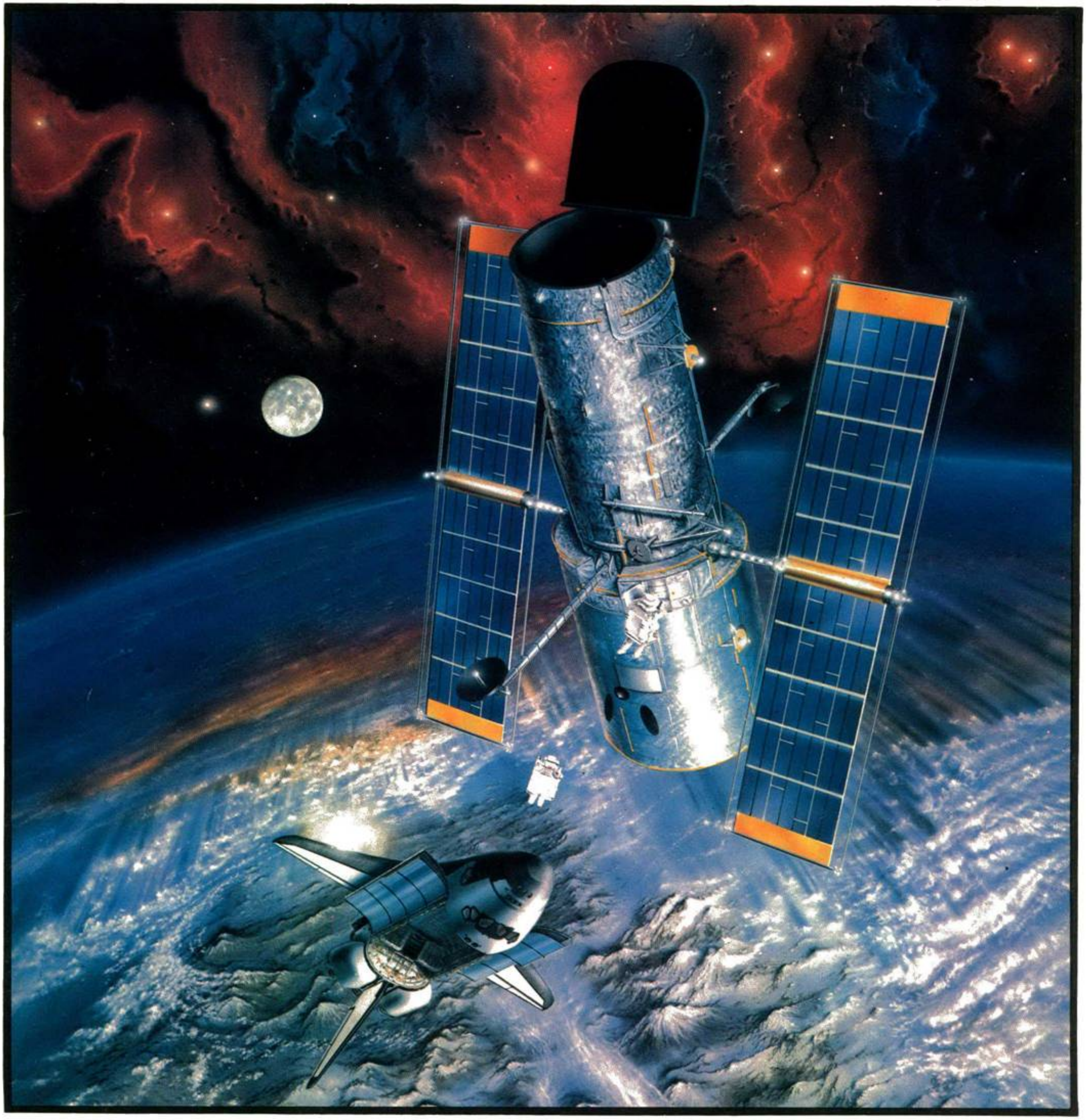
January 1986
U.S. $2
UK £1.50
Can. $2.50

The Universe in Deep Time

How to See Comet Halley

Spark Up Those Dull Astrophotos

ICD# 08070



The Hubble Space Telescope

Meade® Quartz S/C's:

Meade
QUARTZ
Meade
N
E
W
S
Quartz
Manual
Sidereal
Solar
Lunar
Drive Corrector
Power 12V.D.C.
Reticle
Map
Dec
Reticle Adjust
Meade QUARTZ LX DRIVE

The Quantum Leap.

Meade 8" Model 2080/LX3 and 10" Model 2120/LX3, with Quartz Electronic Drive Systems: the most advanced Schmidt-Cassegrains ever manufactured for the serious amateur. Consider these state-of-the-art features:

1 Certified Optics: All 8" and 10" LX3 optics are hand-matched, laser-tested, and individually certified in writing by Meade Instruments to yield the finest diffraction-limited Schmidt-Cassegrain performance obtainable from any manufacturer.

2 New Quartz Electronic LX Drive System: Ultraprecise quartz micro-electronics augment the superb Meade LX Worm Gear Drive, to achieve *true sidereal-rate tracking.* Input-frequency is accurate within ± .005% of the sidereal frequency, *independent* of ambient temperature and local power line frequency variations.

3 Plug-In Single- or Dual-Axis Drive Corrector Capability: No drive corrector chassis boxes to fool with! All electronics are completely self-contained within the LX3 drive base — just plug-in the optional R.A. or Dual Axis control box and use. In the Dual-Axis mode, the Declination motor plugs directly into a jack on the LX3's power panel.

4 A.C. Operation: A 25-ft. power cord with self-contained 115 volts A.C. converter is included with each 8" and 10" LX3 model, yielding 12 volts D.C. input to the telescope's power panel. A red L.E.D., located adjacent to the power input jack, indicates proper power connection.

5 Field Operation: Meade LX3 models operate from 12 volts D.C. and may be powered *directly* from your auto cigarette lighter plug, using the standard-equipment D.C. power cord — *no drive corrector or inverter unit is required for field operation!* LX3 models may even be independently powered in the field, away from your automobile, with the optional Meade Power Cell.

6 Power Panel Output Jacks: The Meade 12mm Illuminated Reticle Guiding Eyepiece and red L.E.D. Map Light plug directly into jacks provided on the power panel, eliminating the need for separate battery packs.

7 8 x 50mm Illuminated Reticle Polar Viewfinder: The illuminated, precisely-etched reticle scale permits extremely accurate polar alignment.

8 x 50mm Polar Viewfinder: with illuminated-reticle and self-contained L.E.D. battery pack.

The Meade 8" Model 2080/LX3: The next generation S/C from the World Leader.

8 Equatorial Wedge with Magnetic Compass, Latitude Scale, Bubble Level, and Micrometric Azimuth Control: This Meade exclusive facilitates *fast, easy* polar alignment even if the Pole Star is not visible from your observing location.

9 Piggyback Camera Bracket: This useful accessory, again included with all LX3's, attaches directly to the telescope's rear cell, for wide-field astrophotography using your 35mm camera.

10 Multi-Coated Diagonal Prism: The Meade Multi-Coated diagonal yields the highest light transmission (over 98%) of any production diagonal available, mirror or prism.

11 High Transmission (MgF_2) Coatings on the Correcting Plate: These coatings substantially increase correcting plate light transmission throughout the visual spectrum.

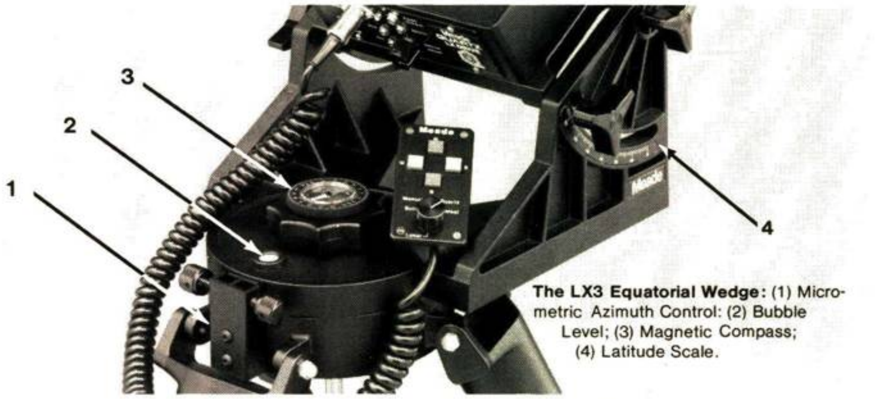
12 Optional Multi-Coated/Silvered Optics Group: *The revolutionary MC/SO Group achieves virtual maximization of transmission/reflectance on every optical surface, and increases total light transmission by approximately* **23%** *over standard Meade 8" and 10" Schmidt-Cassegrains.* The Group includes (1) Multi-Coated aluminized primary mirror; (2) Multi-Coated silvered secondary mirror, in place of standard-aluminized mirrors; and (3) Multi-Coated correcting plate in place of standard MgF_2 coatings (item 11 above).

13 Audio Cassette: This useful tape, provided with every LX3 telescope, explains in detail the features, set-up, and applications, both visual and photographic, of your telescope.

14 Lifetime Warranty: Meade 8" and 10" LX3 Schmidt-Cassegrains, excluding batteries, *are warranted for life* in the U.S.A. and Canada. See the Meade General Catalog for details on this warranty — the most extensive in the industry.

The best news of all . . . Meade LX3's are priced competitively with other Schmidt-Cassegrains offering only a fraction of the LX3 features. Discover them now at your Meade dealer. You'll see why Meade Instruments is the World's leading manufacturer of astronomical telescopes for the serious amateur.

And the first to make a true Quantum Leap in Schmidt-Cassegrain technology.



The LX3 Equatorial Wedge: (1) Micrometric Azimuth Control: (2) Bubble Level; (3) Magnetic Compass; (4) Latitude Scale.

U. S. and Canada Dealer Locations & Assistance

For your nearest Meade dealer location, or for free telescope information and assistance, call Meade Instruments **toll-free** from anywhere in the continental U.S.A, (except Calif.):

1-800-854-7485

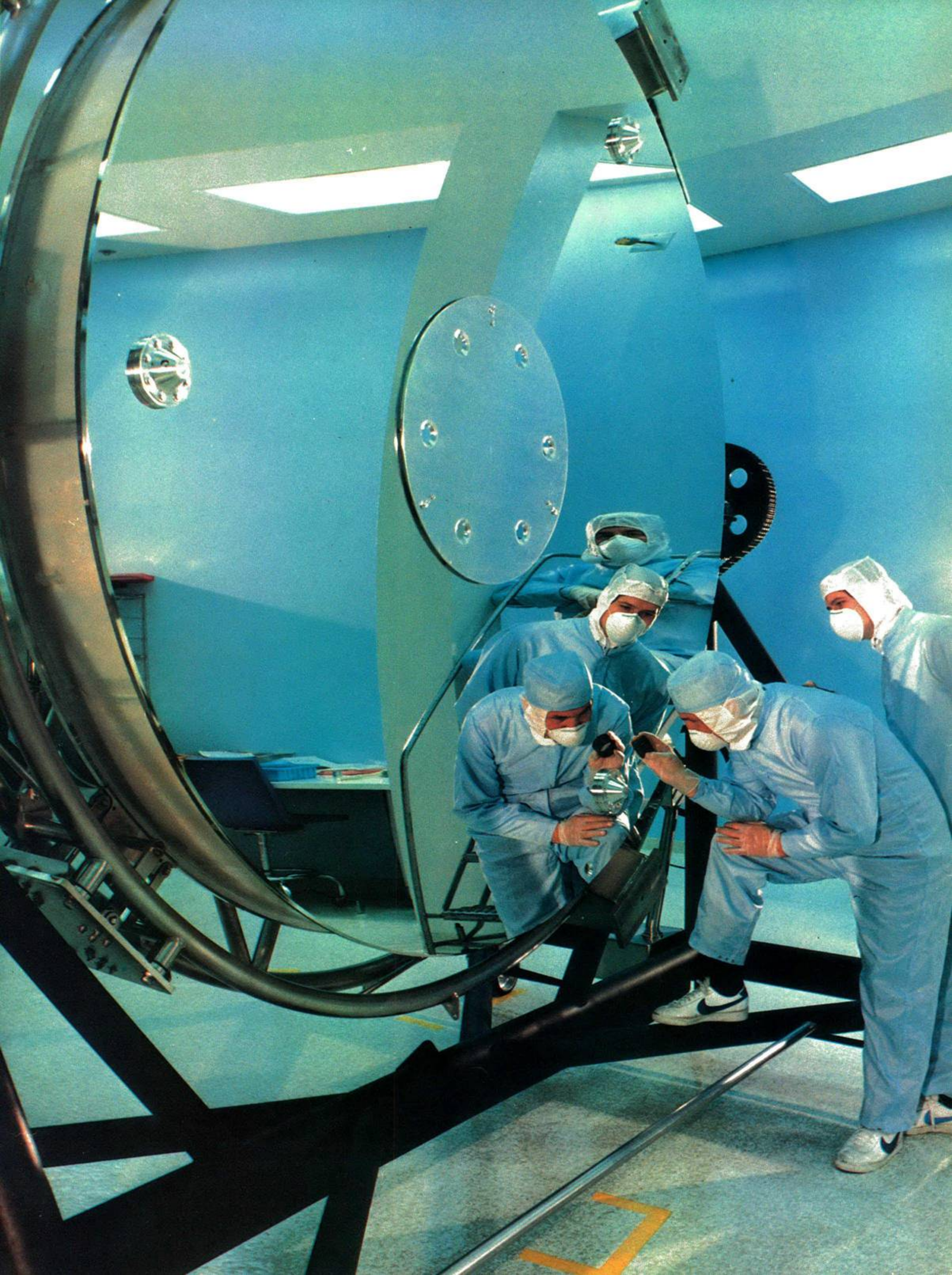
From all other areas, including California, call direct: **(714) 556-2291**

General Catalog - $3.00

Send $3.00 for your copy of the Meade full-color **General Catalog #85C,** with many astrophotos through Meade telescopes and complete details on the entire range of Meade precision astronomical telescopes, spotting scopes, telephoto lenses, and accessories. Meade General Catalogs are forwarded by return First Class Mail.

Meade Instruments Corporation
1675 Toronto Way, Costa Mesa, Calif. 92626 ☐ (714) 556-2291

© 1985



ASTRONOMY

Vol. 14, No. 1

January 1986

The World's Most Beautiful Astronomy Magazine

Editor-in-Chief
Richard Berry
Managing Editor
Stephen Cole
Art Director
Thomas L. Hunt
Senior Editor
Robert Burnham
Assistant Editor
David J. Eicher
Assistant Art Director
Susan R. Myers
Typographer
Mary MacAdam
Designers
Jane Borth Lucius
Patricia LaBrecque
Editorial Assistants
Diane Kendzie-Holdaway
Susan M. Ryan

Publisher
Robert A. Maas
Advertising Coordinator
Dana-Lynne Terry
Product Manager
Susan Poole
Circulation Director
Kristie Fischer
Circulation Manager
Rosemary L. Pickart

Advertising Dept.
(414) 276-2689
Adv. Rep. — NE Region
Adpress, Inc.
New York, NY 10016
(212) 679-1710
U.S. Newsstand Distribution
I.C.D., The Hearst Corp.
New York, NY 10019
Canadian Newsstand Dist.
Telemedia Dist.
Toronto, Ontario M4S 3B3
World Newsstand Distribution
Boarts International, Inc.
New York, NY 10019

6 **Deep Time: The Fate of the Universe**
by David Darling

14 **Building the Space Telescope's Optical System**
by Gary Watson

Forum 24 **The Main Sequence Blues**
Stalking An Asteroid's Shadow

Gazer's Gazette 30 **Amateur Astronomers Observe Halley's Comet**
by David J. Eicher

In Focus 38

Behind the Scenes 39

Astronomy Reviews 42

Equipment Atlas 47 **Sundials**
by Basil O'Fee

Eye on the Sky 54 **Halley's Show in the Evening Sky**
by Fred Schaaf

Photography in Astronomy 62 **How to Revive Dull Astrophotos**
by Ben Pate

AstroNews 74

AstroCalendar 79

AstroMart 85

Stellar Frontiers 90 **Astronomy and Astrology: East vs. West**
by George Reed

Gazer's Gazette 99 **Chasing the Ogre**
by Bill Katz

The Backyard Astronomer 102 **Auriga**

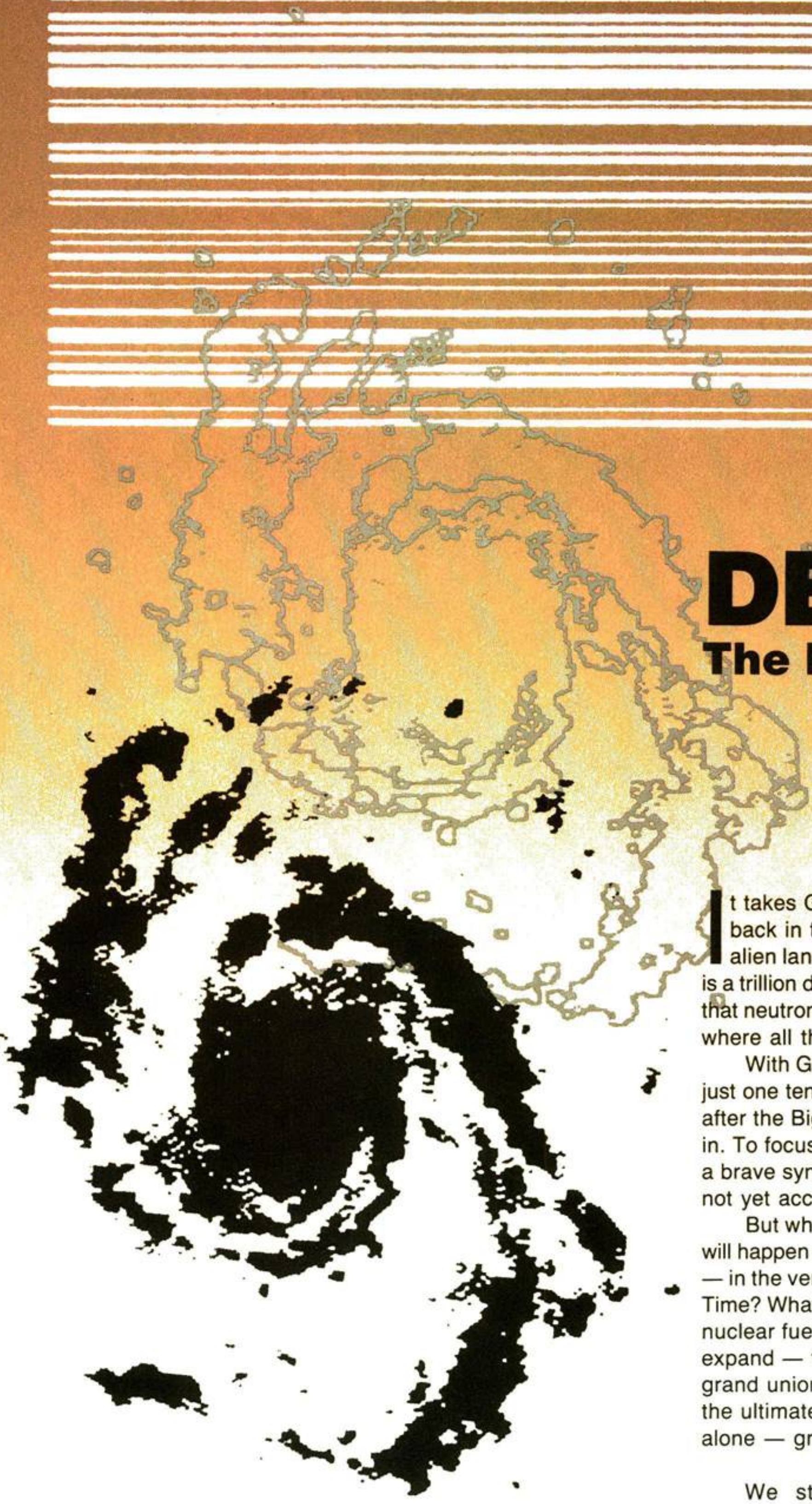
Cover: The Hubble Space Telescope will give astronomers an unprecedented view of the universe. This month, ASTRONOMY's second feature article examines how teams of opticians and engineers made the system's ultra-precise mirrors; our first feature explores the strange realm of the very distant future. Opposite page: Technicians take a close-up look at the giant primary mirror of the Space Telescope. Photos courtesy Perkin-Elmer Corporation.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia, a division of Kalmbach Publishing Co., 625 E. St. Paul Ave., P.O. Box 92788, Milwaukee, WI 53202.

Copyright © 1985 Kalmbach Publishing Co., all rights reserved. Material in this publication may not be reproduced in any form without permission.

Second class postage paid at Milwaukee, WI and additional mailing offices. POSTMASTER: Send address changes to ASTRONOMY, P.O. Box 92788, Milwaukee, WI 53202. Questions about subscriptions and product orders: (414) 276-8547 weekdays, 8am - 4pm. Allow six to eight weeks for new subscriptions and changes of address. New subscriptions start with current issue. Subscription price: 1 year, $21.00. All foreign: add $5.00 per year; please remit in U.S. funds. Send editorial and business inquiries and submissions to the address above. Telephone: (414) 276-2689. Not responsible for unsolicited materials. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of ASTRONOMY available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 46691. Printed in the U.S.A.

ABC



DEEP TIME

The Fate of the Universe

by David J. Darling

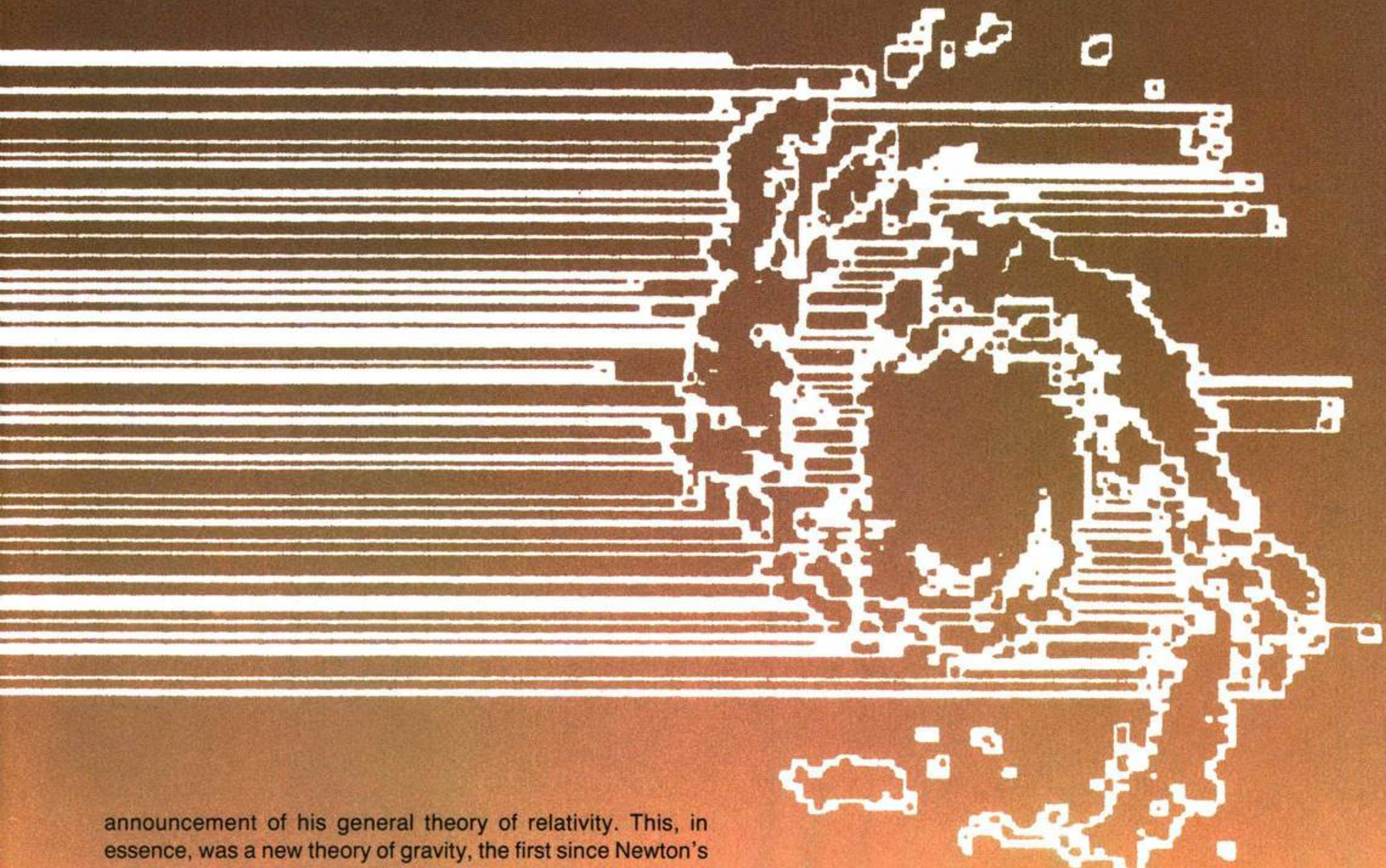
It takes GUTs — Grand Unified Theories — to probe far back in time to the origin of the Universe. There, exotic alien landscapes beckon: regions where the temperature is a trillion degrees in the shade, where the density is so great that neutron star matter seems like a vacuum by comparison, where all the forces of nature are one.

With GUTs, we can dimly glimpse events that occurred just one ten million trillion trillion trillionth (10^{-43}) of a second after the Big Bang itself. Before that, hopeless myopia sets in. To focus on still earlier microstrata of time, we will need a brave synthesis of nature's four basic forces, a synthesis not yet accomplished.

But what of the far distant future of the Universe? What will happen to the Universe we know — the stars and galaxies — in the very distant future, in the mysterious realm of Deep Time? What will happen when the stars have exhausted their nuclear fuel? What will happen if the Universe continues to expand — forever? To predict that, we need not await that grand union sought so feverishly by particle physicists, for the ultimate fate of the Universe is in the grip of one force alone — gravity.

An Open or Closed Question

We step back in time to 1915 and Einstein's



announcement of his general theory of relativity. This, in essence, was a new theory of gravity, the first since Newton's in the 17th century. Through it, gravity became synonymous with the geometry of space or, strictly speaking, space-time. An old analogy prods our imagination. Represent the three-dimensional space around us by a taut, two-dimensional rubber sheet. Ball bearings dropped on the surface of that sheet correspond to objects with mass in real space. The greater the weight of the ball — the more massive the object — the deeper the depression, or warp, it makes in the surrounding elastic skin. We can interpret the analogy like this: gravity is an illusion; the "gravitational force" felt near any object is due to a local curvature of space — warping — caused by the object's mass.

In reality, of course, space is not a two-dimensional surface curved by metal masses in a third dimension. Unnervingly, it is a three-dimensional surface curved through a fourth dimension, and our minds begin to rebel at the prospect. Worse still, as Einstein showed, because of the intimate link between space and time, it is not space alone that is deformed but also time — space-time. (For simplicity's sake, we'll use the word space to mean "space-time.")

Within small regions, then, massive objects — planets, stars, galaxies, and so on — bend the space around themselves, and we interpret this as gravity. But what of larger regions? What, in fact, does relativity predict about the curvature of space on a cosmic scale?

Here, Einstein's theory makes an even more startling prediction, though Einstein himself uncustomarily missed it. So concerned was he that the Universe should be of a particular type that he introduced into his equations a fudge factor — the infamous "cosmological constant" (see "Discovering the Expanding Universe," ASTRONOMY, February 1985).

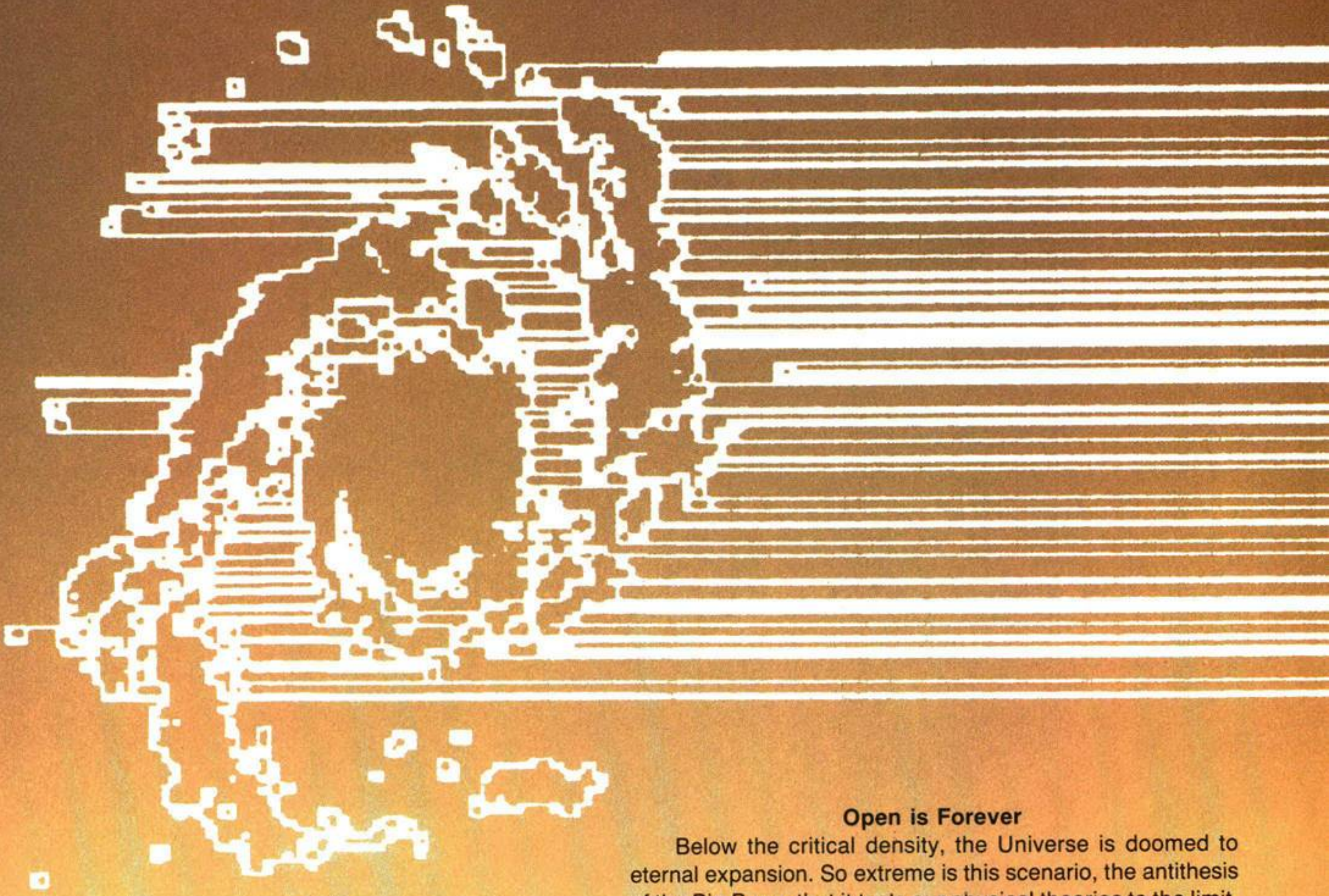
As Einstein himself later admitted, it was a blunder. On the basis of scant observational evidence, he had inferred that the Universe must be static, unchanging. Yet the equations of general relativity, as they stood, called for an evolving cosmos.

The true dynamic solution to the original equations was extracted in 1922 by the Russian mathematician Alexander Friedmann. His work has formed the cornerstone for our standard cosmological models ever since.

Basically, Friedmann's solution predicts that (a) the Universe must be evolving, and (b) it must be either closed or open. In a closed universe, space is so strongly curved — "curved" in the same sense space curves around a massive object — that it folds back on itself, giving the Universe a definite overall size. The two-dimensional analog of the closed universe is a sphere. On the other hand, in an open universe space curves gently outward without end. Here, the two-dimensional analog is the saddle-shaped surface of a hyperboloid.

The key factor in determining which type of universe we actually live in is the average density of matter throughout space. If there is sufficient matter in the Universe — an amount greater than the so-called critical density — the Universe would bend space back on itself and thereby close space. The resulting universe would have a finite overall size. At or below the critical value, there is too little mass, so the Universe, though still curved, would be open and infinite. No other possibilities are allowed under the constraints of the standard model.

So, we ask, which is it? Are we dwellers in an open or closed cosmos? That question could be settled in an instant if we had exact knowledge of one thing: the amount of "dark" matter the Universe contains.



Totaling up all the luminous, visible mass — all the stars and glowing gas in all the galaxies — we come up with only about 1% of the mass necessary to close space. Bright matter, it seems, is a poor brakeman. If it were all the Universe consisted of, the outward blast of the Big Bang would go virtually unchecked.

But there is more to our Universe than meets the eye. Dark, "hidden" matter may, in fact, rule. From studies of the motion of galaxies in clusters (see "Mystery of the Missing Mass," ASTRONOMY, November 1984), comes the gradual realization that the bulk of cosmic mass is in a form we cannot see. Scattered across the lonely gulfs between galaxies or assembled into mighty, invisible appendages of the galaxies themselves, it is the mass we cannot see that holds the key to the fate of the Universe.

So a fundamental question for today's cosmologist is: What guise does the dark matter take? The list of suspects reads like a script from a 1950s sci-fi movie: magnetic monopoles, gravitinos, massive neutrinos, mini black holes, and axions — not a remotely conventional candidate among the lot.

Another question regarding the dark secret of the Universe, one that's more pertinent to our quest, is how much unseen matter is there? Enough to close space? At present, the answer is tantalizingly beyond our grasp. Without doubt, there is a great deal of dark mass — between ten and a hundred times as much as bright mass. Is it sufficient to close the Universe? We cannot yet say.

In projecting the future of the Universe, then, we must consider both possibilities. Either way — open or closed — the future we're moving toward is bizarre.

Open is Forever

Below the critical density, the Universe is doomed to eternal expansion. So extreme is this scenario, the antithesis of the Big Bang, that it tests our physical theories to the limit.

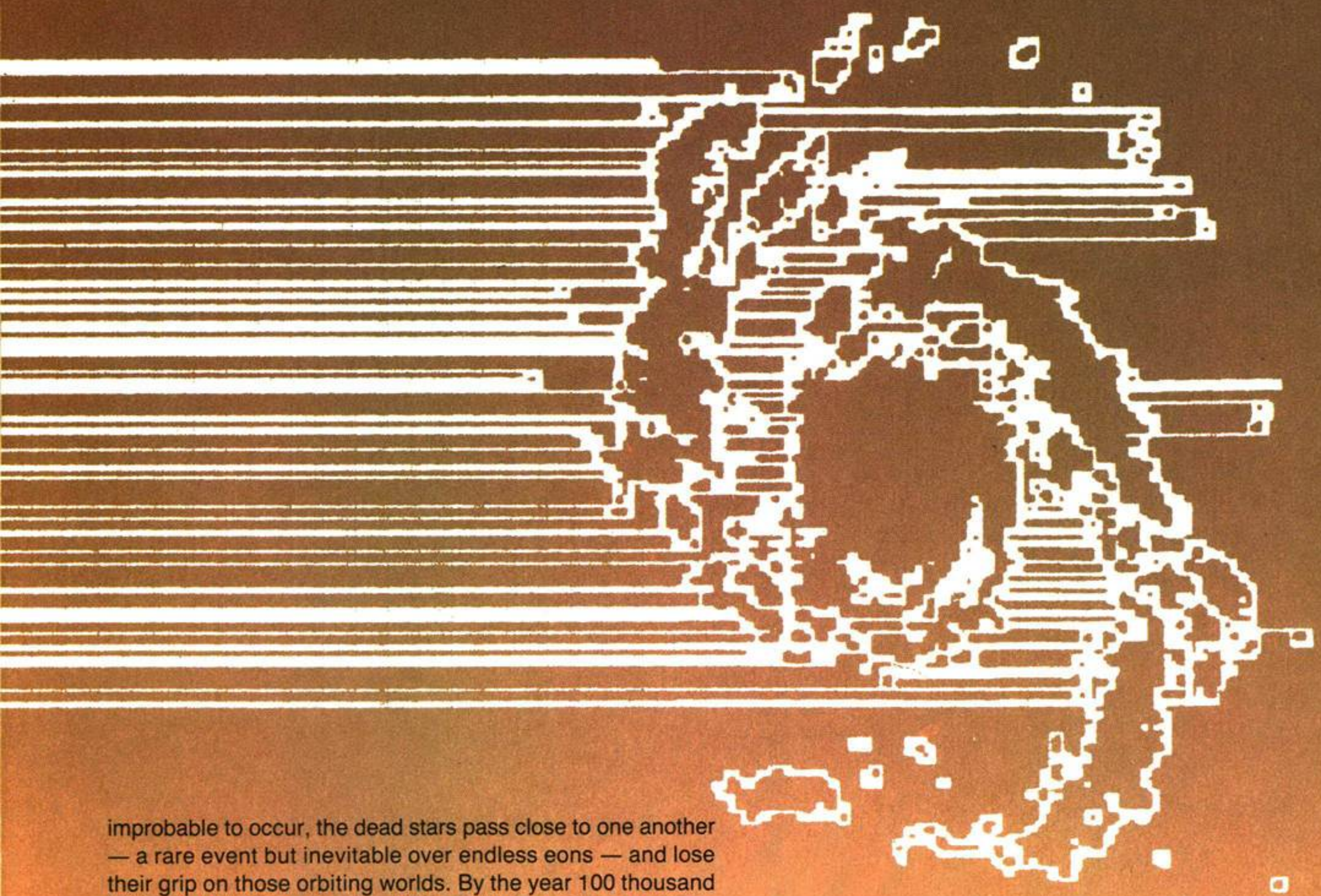
We now set out on a weird voyage into Deep Time. Our starting point is today — a mere 18 billion years since the Big Bang, give or take a few billion years. Let another billion years pass and the universe expands a bit. Let 10 billion years pass and some new stars form while old stars die. But let 100 billion years fly past and our Local Group of galaxies lies alone — a small island of matter in an ever-widening ocean. The nearest galaxies are dim points in our largest telescopes. And the galaxies are changing.

Stars are burning out. Spiral galaxies like our own Milky Way, once fertile star-making fields rich in gas and dust, are used up. The golden epoch of stars is over. Even the cool, low-mass, red-dwarf stellar Methuselahs of the core, halo, and the ancient elliptical galaxies are aging into senescence.

We reach the trillion year mark and the cosmos is a place vast, dim, and ruddy-glowing with the cooling corpses of stars. Leaping forward another 10 trillion years, the era of living stars is almost at an end.

We stride ahead again, to the year 100 trillion (10^{14}) A.D. Now every star in space has consumed its useful fusion energy reserves and subsided under self-gravity, becoming a cold, dark cinder. The most common objects in that far-off age are the remnants of small stars — hot, planet-sized balls of electrons and burnt-out nuclei called white dwarfs. Rarer are the dense cinders of heavier suns — the neutron stars. Even rarer, though in far greater numbers than today, are the dark, sinister carcasses of the heaviest stars — black holes.

Still wheeling in their orbits about expired stars are systems of planets charred when their parent suns expanded to red-gianthood. As we venture further into Deep Time, these systems begin to break up. Given enough time for the



improbable to occur, the dead stars pass close to one another — a rare event but inevitable over endless eons — and lose their grip on those orbiting worlds. By the year 100 thousand trillion (10^{17}) A.D., nearly all the planets ever formed are drifting untethered through the interstellar void.

But stellar encounters, when close enough, do more than rip planets free, they also pull galaxies apart. The gravitational "slingshot" effect used to redirect probes on multi-planet missions reminds us why. As Voyager 2 encountered Saturn in August 1981, it purposely followed a path that would utilize Saturn's gravity pull to hurl it on course, at increased speed, toward Uranus. We could not measure it, but the kinetic energy Voyager gained was at Saturn's expense. The sixth planet was slowed minutely in its orbit and made to fall imperceptibly toward the Sun.

In Deep Time, dead stars in all the galaxies experience the slingshot effect over and over again. Multiple close encounters throw many stars into intergalactic space. One million trillion (10^{18}) years hence, up to 90% of the mass of every galaxy has evaporated in this way. The remaining 10%, robbed of kinetic energy by the same near-collisions, has been sucked by the galactic gravity field into an increasingly dense core. The galaxies themselves are disintegrating.

We have reached a stage of the open universe 100 million times further from the Big Bang than our cosmos is today. The Universe is dark. What little light remains comes from tepid white dwarfs and neutron stars that have escaped their parent galaxies. And the galaxies, at least what remains of them in the form of supermassive black holes, no longer shine at all. Some galaxies have harbored black holes in their cores, if current ideas are correct, almost since the cosmic dawn. In any event, galactic-scale black holes are almost certain to result following the great star exodus as the increase in central density causes the remaining stars to collide and be gobbled up.

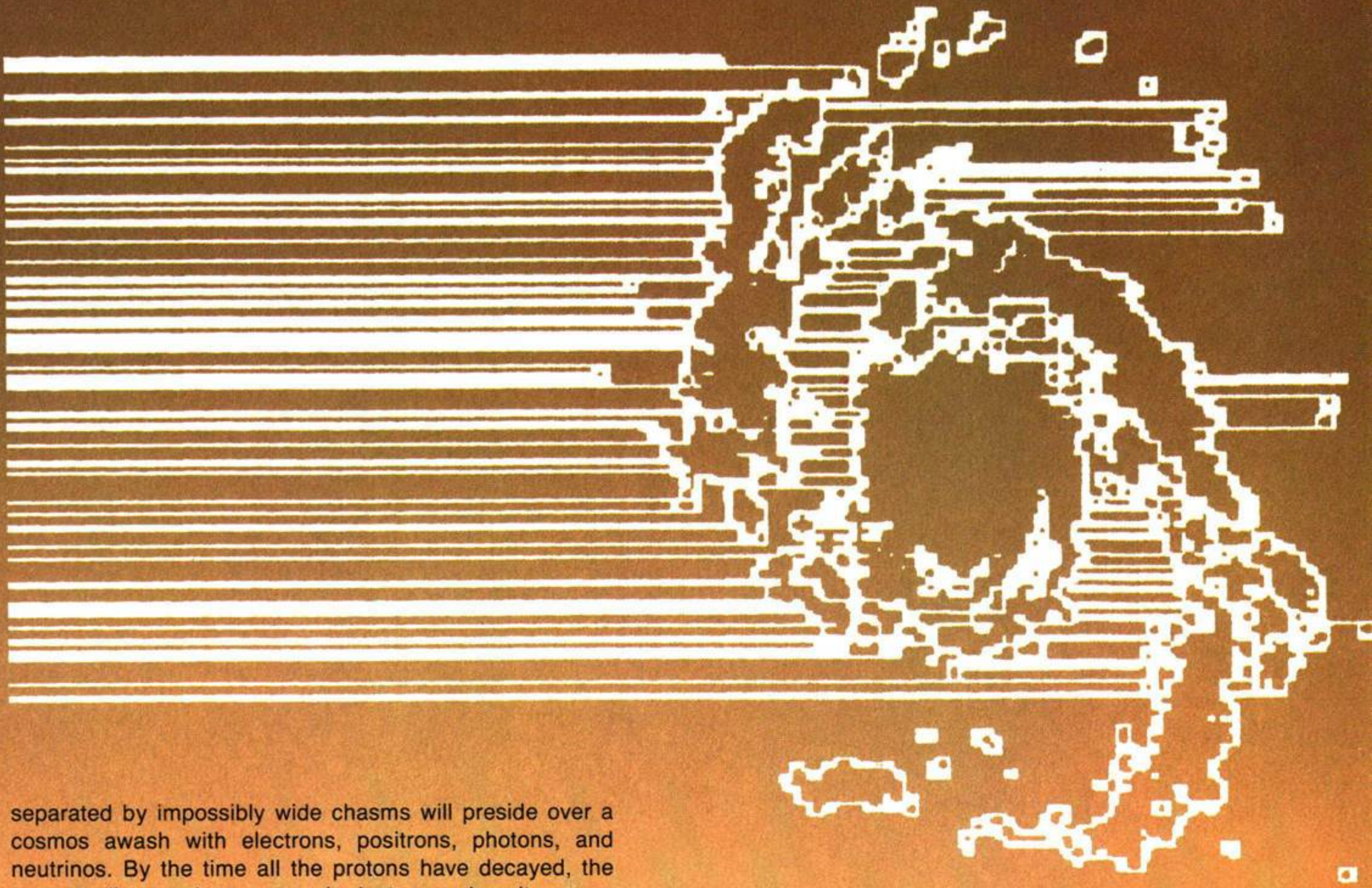
Planets without stars, stars without galaxies, and everywhere the ruin of gravitational collapse — what further deterioration could an open universe suffer? Voyaging further into Deep Time, we pose questions and seek answers.

The expansion of the Universe continues; it swells grotesquely. Stars that have avoided being swallowed by monster black holes or have collapsed in gravity pits of their own making survive on, glowing dimly in the far infrared. The realization has been slow-dawning, but there can be no mistake: Dead stars that have had time enough to chill to the ambient frigidity of space remain warm! Somehow they continue to generate their own heat.

What solution is there to this apparent paradox? It comes from the looking-glass world of particle physics, whose influence also bears powerfully on the problem of the Universe's genesis. A curious new prediction of the science of the very small is that the proton — a basic building block of normal matter — may be unstable. It is, however, a very durable brand of instability, to say the least. Present estimates suggest that it will take between one and 100 million trillion trillion (10^{30} to 10^{32}) years for all the protons in the Universe to disappear!

Yet that vast period falls well within the scope of an infinite, open universe. Indeed, it is through the products of proton decay that the otherwise lifeless stars in the cosmos beyond 100 million trillion (10^{20}) A.D. will be slightly warmed — the heaviest of them to about 100° above absolute zero. But this is only a temporary reprieve from oblivion. Once the protons have gone, at an agonizingly slow rate, there will be no more stars.

And as the protons decay, there will be no organized matter left in the Universe. Supermassive black holes



separated by impossibly wide chasms will preside over a cosmos awash with electrons, positrons, photons, and neutrinos. By the time all the protons have decayed, the average distance between each electron and positron may be greater than the diameter of a present-day galaxy. The Universe as a whole has grown to perhaps 100 million trillion (10^{20}) times larger than it is now by the year 10^{30} A.D. — and it will be growing still.

But even at this mind-bending stage our journey is not over. The supermassive black holes themselves — those dark fossils of galaxies once ablaze with starlight — are evaporating. It is a slow, slow process. But, as astrophysicist Stephen Hawking showed some years ago, particles can, because of the strange rules of quantum mechanics, escape through a black hole's "surface" or event horizon. Mass and energy are gradually lost in this way by all black holes, the rate of loss depending on the size of the hole. For galactic-scale black holes, total evaporation by "Hawking radiation" should take about 10 thousand trillion trillion trillion trillion trillion trillion trillion trillion (10^{100}) years.

A long time to wait for the final predictable scene of the open universe? Perhaps. But our patience is rewarded: as the supermassive black holes shrink, the rate at which they emit particles and radiation increases. Finally, as they disappear, they explode spectacularly. The open cosmos ends with a fireworks display!

But the *Universe* never really ends. An open universe goes on forever, growing ever bigger, colder, darker, and increasingly tenuous. Or does it?

Spill a cup of coffee over your desk. There is a very, very slim chance that all the coffee will spontaneously hop back into the cup again. Admittedly, the odds are great and field tests could prove messy. But with an open universe, we are talking about colossal time scales. Along the path to eternity, there is ample opportunity for even a super-thin soup of particles to regroup, by chance, into a blob of matter, a star, a galaxy, or anything else. Open space offers an infinity of choice — if you are prepared to wait long enough.

The Big Crunch

A sufferer of vertigo, I prefer the other theoretical option: a closed cosmos. If the Universe contains enough matter — either luminous or dark — it can fold the fabric of space back on itself. And a weird thought suddenly comes to mind: the Universe must then be a black hole, for the definition of such an object is a region of space (whatever size) from which nothing — not even light — can escape.

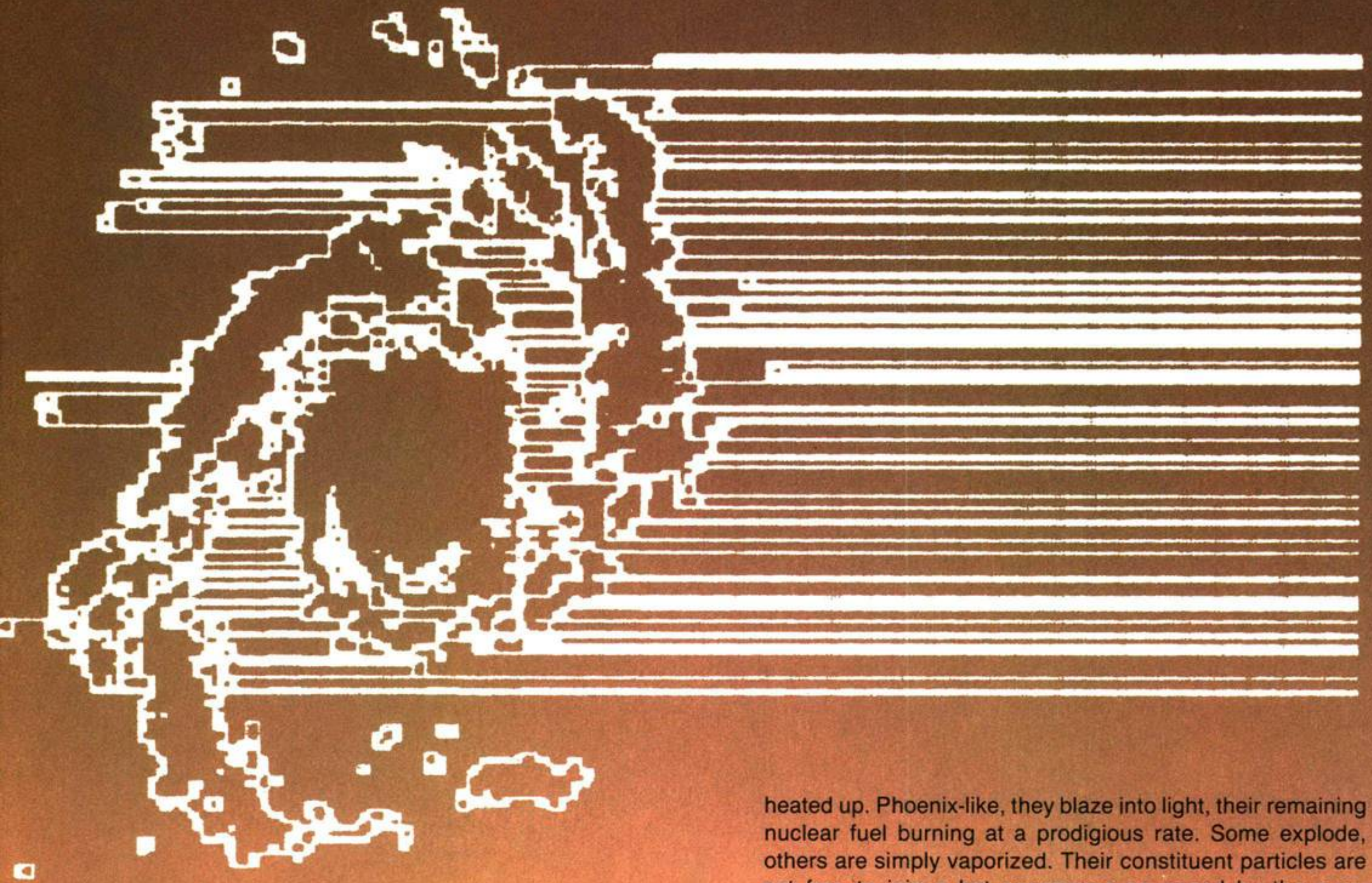
If closed, the Universe has always been closed and always will be. We live in a monumental black hole that is growing, but slowing in its growth. Running the clock forward, we surmise its destiny.

The outward rush of the cluster of galaxies will continue. Even generous estimates of the cosmic mass cannot avoid a lengthy expansion phase. A trillion years might be conservative, the upper limit indefinitely large. Whatever the time frame, the Universe will expand until the critical cosmic density is reached.

If the Universe is closed, it may quite possibly go through one or more of the key phases of the open model's evolution. The exhaustion of all stars, escape of their planets, and breakup of galaxies are the most likely. But a longer period of expansion could encompass every effect up to and including the "popping" of supermassive black holes.

If it is closed, however, the Universe must eventually reach some maximum size after which it will begin to contract. New phenomena not seen in the open universe scenario would then come into play.

We materialize in Deep Time at the instant of reversal.



Our closed cosmos has just started to deflate like a gigantic balloon that has sprung a slow leak. But wait. Something odd is happening. The total energy of the Universe has begun to rise: the conservation of energy no longer applies. We suddenly spot the reason. The myriad of photons throughout space — the cosmic background radiation — is now being Doppler-shifted but toward the blue end of the spectrum. As the contraction of the Universe picks up speed, photons are blueshifted more and more and thereby are made increasingly energetic. Eventually they will surpass the energy with which they were first emitted!

We travel on and after countless eons we reach a time when the Universe has fallen back to its present size — but it is not the universe as we know it now. The temperature of the cosmic background radiation has reached 3° above absolute zero, but the stars are cold, black cinders.

As the temperature of the Universe continues to rise, the volume of space shrinks and shrinks. When it reaches the size it was just one billion years after the Big Bang, the clusters of galaxies start to merge into a single, vast hypercluster containing all the galaxies that ever were. The hypercluster itself shrinks until the galaxies within it start to merge. The cosmos continues to collapse, shrinking to the size it was just one million years after the Big Bang. Stars rush crazily toward each other at relativistic speeds.

And another extraordinary thing is happening. Because of the steeply rising blueshift of free photons in space, the night sky is becoming intensely hot. Around the year 100,000 B.D. (Before Doomsday), the temperature throughout space reaches that of an average present-day star's surface. Burnt-out remains of stars — assuming any have survived — are heated up. Phoenix-like, they blaze into light, their remaining nuclear fuel burning at a prodigious rate. Some explode, others are simply vaporized. Their constituent particles are set free to join a hot *consomme* squeezed by the ever-contracting boundary of space.

We penetrate further still into Deep Time. Now the Universe is shriveled to a size it knew just one year after its birth. The black holes have begun to feast voraciously. First they gobble up much of the boiling, 100-million-degree soup around them, then, unsated, they cannibalize each other, growing fewer and larger in number. Were this to go on, it would ultimately result in a single black hole the size of the remaining cosmos — a black hole within a black hole, so to speak. But we have now entered an uncharted land and our present theories leave us guessing.

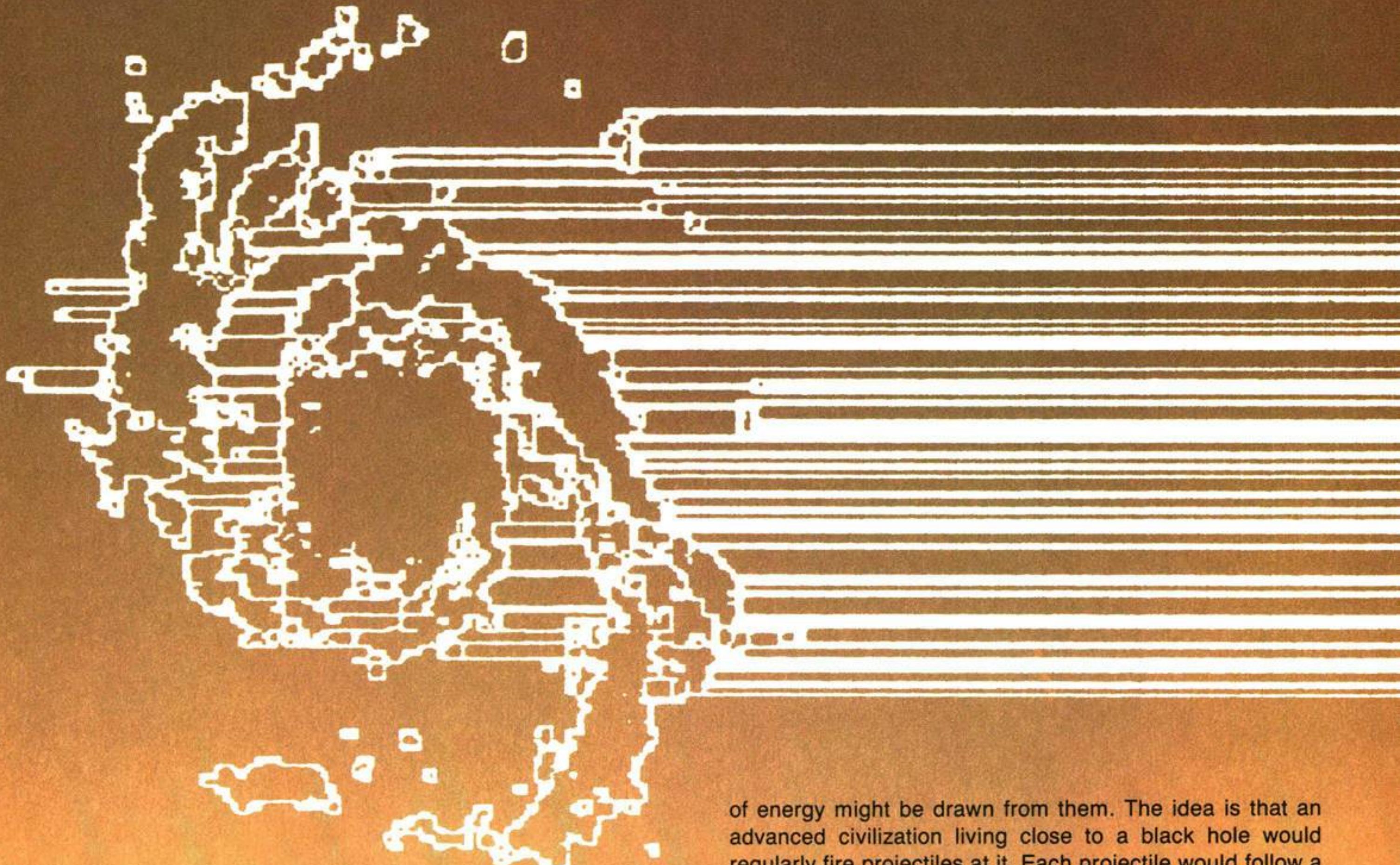
One possibility is that the Universe may bounce, transforming Armageddon into a new Genesis. That, at least, is philosophically satisfying. Taking this hypothesis to its logical conclusion, we arrive at the oscillating model of the cosmos in which the Universe cycles between expansion and contraction with Big Bangs and Big Crunches interspersed. For now, this possibility remains in the realm of conjecture.

The truth is, we may be years away from a verdict even on the simple open *vs.* closed question. In either case, the precise details will surely elude us even longer.

Yet we still dream on. There is more than just a detached, scientific interest in all this for us. At the back of our minds is the prospect of long-term survival, if not as individuals then as a species or an intelligence. So, we reach the ultimate question of Deep Time: can sentient beings survive, in any form, over indefinite cosmic time scales?

The Outlook for Intelligence

Homo sapiens has come a long way in a brief million years. Now even the pace of our ultra-fast physical evolution has been outstripped by rampant sociological change during the last 10,000 years and the unchecked technological



explosion over the last hundred. Compared to our inherent interest in the future of mankind, the destiny of stars, galaxies, and indeed the whole cosmos becomes almost trifling.

Of course, it may be that we shall quickly self-destruct, simplifying matters. But taking the optimistic approach that we somehow survive the present period of instability, what lies ahead? Space colonization, say many. First the solar system, then the nearer stars — terraforming hostile worlds, capturing starlight with Dyson spheres or "ringworlds" (*a la* Niven) as we go.

In the end, however, today's most far-sighted prophecies will surely seem parochial. We have absolutely no idea what our descendants — assuming there are any — will be like in a few million or billion years' time. Mushrooming fields like microelectronics and genetic engineering already suggest some extraordinary possibilities. Within a century, computers could be self-replicating entities with intellects more powerful than our own. Who is to say that what was once human intelligence will not survive in some altered, hugely-amplified form, a blend of the biological and electronic? We might argue about the feasibility or ethics of this today, but one billion years hence a much different morality could apply.

In any event, DNA-based or not, intelligence faces some tough crises over the long term. If the Universe is open, all the stars will eventually die, leaving only big black holes set against a backdrop of subatomic particles. In such an unpromising environment, how would a sentient species fill its energy needs?

One answer could be through the Penrose mechanism. British relativist Roger Penrose has shown that by ingeniously using black holes as garbage disposals, impressive amounts of energy might be drawn from them. The idea is that an advanced civilization living close to a black hole would regularly fire projectiles at it. Each projectile would follow a carefully-charted course to the fringe of the event horizon, where it would jettison a load of waste matter. Tumbling into the gravity vortex, this surplus material would be lost forever, but its total rest mass energy would be transferred to the parent projectile (plus an extra contribution from rotational energy lost by the black hole). The projectile's gained energy could then be converted into a suitable form to supply the civilization's needs.

Again, this is probably a naive suggestion. It takes a lot of arrogance to believe that we have found in the 1980s the unique solution to an energy crisis over one million trillion trillion years in the future. Still, there is comfort in the knowledge that a solution of sorts *does* at least exist.

Once the black holes have boiled away, though, around 10^{100} A.D., matters get decidedly trickier. With the degree of disorder (entropy) of the cosmos almost total, how could intelligence of any sort survive?

Cosmologists like Frank Dyson have some suggestions. According to Dyson, consciousness or intelligence — whatever we want to call it — is intimately linked to complexity. Sentient beings in Deep Time could continue to exist if there were some way to retain local oases of complexity or organization in the growing desert of chaos. This could perhaps be achieved through lengthening periods of hibernation separated by bursts of energy-using activity.

On the other hand, our progeny might find some clever way to avoid the endless cosmic twilight altogether. Long before an open universe winds down, they might simply pop down into a convenient black hole and reappear in a friendlier parallel universe (if any such exist) or reappear in an earlier, more energy-rich phase of our own cosmos. For now, such issues may be left in the capable hands of science fiction writers.

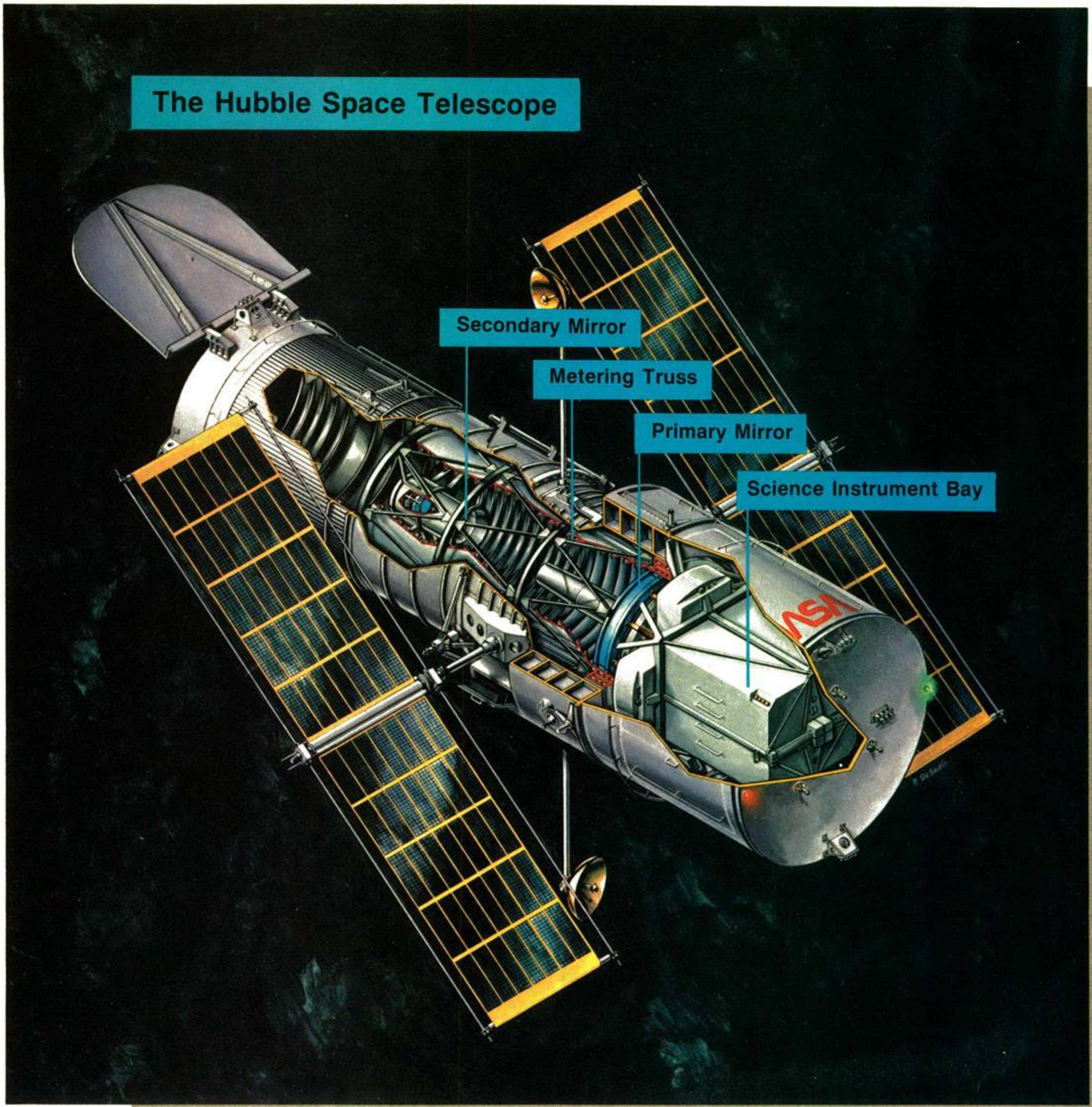
We now turn to the other possibility, that we are living in a closed universe. No energy crisis faces us here, merely the daunting prospect of the coming Big Crunch. What Houdini-like escape could there be, we wonder, from a universe unimaginably smaller than the dot over this "i" that contains all the pent-up energy of a hundred billion galaxies. And, if our descendants do survive such a trauma, what will they find on the other side?

In a cyclic universe, there is a net energy gain during each contraction. That means each Big Bang would be more powerful than the last, so that it would take gravity longer each time to bring the explosion debris back together again. Each cycle, according to some estimates, might have double the lifespan of its predecessor. Whether every cycle would have galaxies, stars, planets, and indigenous life forms is quite impossible for us to say.

Right now, exobiology confines itself to the prospect of life on other worlds. But if the Universe does oscillate, might we not also inquire about life and intelligence in other cosmic cycles? What would it be like? Could consciousness evolve in a universe markedly different from our own, in a universe, for example, without stars? Could it learn how to cross the threshold from one cycle to the next? And if so, are there any primordial cosmic migrants in our Universe now?

It is astonishing enough that we can even ask questions such as these today, never mind that we dare hope to find answers to them. Deep Time stretches before us — a terrible, awesome ravine. But through our mind's eye, we have already begun to cross it and gaze inquisitively at the strange lands beyond.

David Darling is an astronomer and computer scientist living in northern England. His most recent contribution to ASTRONOMY *was "Spectral Visions," parts 1 and 2, which appeared in the August and September 1984 issues. He has recently completed a series of astronomy books for children called "Discovering Our Universe."*


The Hubble Space Telescope
Secondary Mirror
Metering Truss
Primary Mirror
Science Instrument Bay

This cutaway shows the Optical Telescope Assembly in the Hubble Space Telescope. The OTA includes a 94-inch primary mirror, a 12.5-inch secondary mirror, a graphite-epoxy metering truss, and the fine guidance and control sensors. All photos courtesy Perkin-Elmer Corporation.

Building the Space Telescope's Optical System

by Gary Watson

"Like buried treasures, the outposts of the Universe have beckoned to the adventurous from immemorial times." So wrote George Ellery Hale in 1928 when he was promoting the dream that ultimately became the 200-inch telescope on Palomar Mountain. Hale continued, "If the cost of gathering celestial treasure exceeds that of searching for the buried chests of a Morgan or a Flint, the expectation of rich return is surely greater and the route no less attractive."

Seizing on Hale's spirit, NASA is now completing the Hubble Space Telescope (HST) at a cost exceeding that of the 40 largest optical telescopes in the world combined — $1.2 billion. But the expectation of a rich return still beckons, for the Hubble Space Telescope, scheduled to be placed in orbit in late 1986, will far surpass the power of Palomar, Hale's greatest instrument. If the Space Telescope meets its design goals, it will see seven times farther into space than any telescope has before. It will be able to detect objects 50 times fainter than the largest ground-based telescopes can and separate objects as little as 1/10 arc-second apart — a tenfold improvement over what the 200-inch telescope normally manages.

HST won't be particularly large by ground-based standards; at 94 inches, it has less than half the aperture of Hale's 200-inch. Since atmospheric turbulence will not mar or distort the perfection of its optical system, HST will have to contain the finest large optical system ever built. Many years of work have gone into the ultra-accurate "figuring" process. Opticians have had to devise new methods for shaping and coating an ultra-light mirror, pushing modern optical technology to its very limits.

HST has been long in the making. In the early 1960s, it became evident that NASA would eventually be able to place a large telescope in orbit above the disturbance and absorption of Earth's atmosphere. The orbiting telescope concept was formally recommended in 1965, and by 1977, Congress had approved funding for it. In October of that year, the Perkin-Elmer Corporation of Danbury, Connecticut, began work on the all-important optical system.

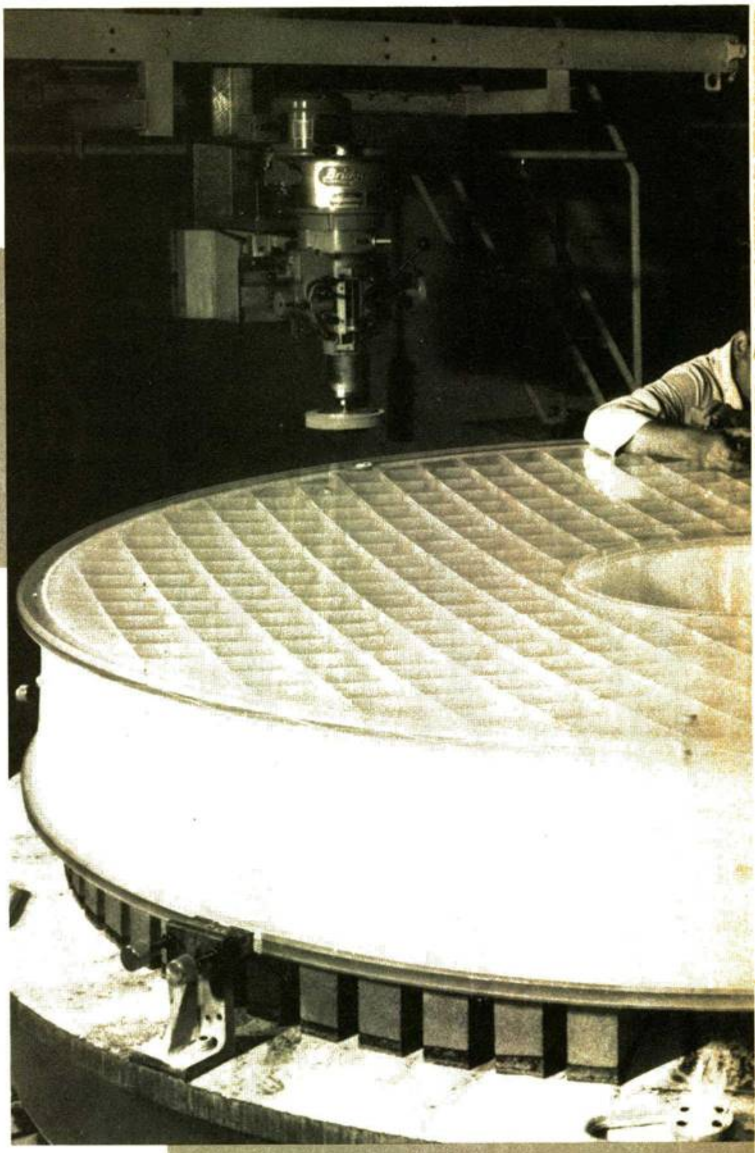
HST's optical system consists of two mirrors: a 94-inch primary mirror that gathers starlight and bounces it forward to the 12½-inch secondary mirror, which then redirects light back to a hole in the primary mirror. Here the light enters the scientific payload — sensitive instruments that picture and measure light. Holding these mirrors and the instruments precisely in place is a framework called the metering truss. Making these components and making them right was Perkin-Elmer's demanding task.

The project began with an order for the glass disk from which the primary mirror would be fabricated. NASA had decided that an extraordinary glass manufactured by the Corning Glass Company — Ultra Low Expansion (ULE) glass — would be the best material for the mirror. In space, HST will undergo large and frequent temperature changes. ULE's most important characteristic is its essentially zero coefficient of expansion at room temperatures. This means that when the temperature changes, a mirror made of ULE will not expand or distort and will thereby retain its surface precision.

Another unusual property of ULE glass is its weldability. Thin slabs can be fused together to fabricate a disk with square-celled, monolithic, honeycomb cores. Such a disk weighs only one-fourth as much as a solid piece of glass. For a space telescope, weight is at a premium, so this is a very attractive feature. Furthermore, there is a linear relation between thermal expansion and the velocity of high-frequency sound waves in ULE glass. This property permits nondestructive testing using sound waves to verify that the glass meets NASA's stringent requirements for zero expansion.

Corning delivered the primary disk to Perkin-Elmer one year after receiving the order. Although it measures almost eight feet in diameter, it is one of the lightest large

". . . pushing modern optical technology to its very limits."



mirrors ever made. Its mass was reduced by making the mirror hollow. The mirror was built from a welded honeycomb core 10 inches thick with one-inch-thick plates, front and back, fused to the core. Each hollow is vented so that air can escape when the telescope is launched into space. The disk cost $750,000 and weighs only one ton. Compare that to the 14-ton weight of the 200-inch telescope's mirror! Indeed, the mirror of the 200-inch alone weighs more than the entire Space Telescope Observatory (25,500 pounds).

But the glass disk was only the raw material; the optician's art was needed to give it life. Before Perkin-Elmer's opticians could begin their work, they had to know how accurately they would need to make its surface. The company had contracted to build an optical system capable of reflecting light to a focus with a total error no greater than 1/20th of the wavelength of helium-neon laser light. A telescope rated at 1/20-wave, in opticians' jargon, is virtually perfect.

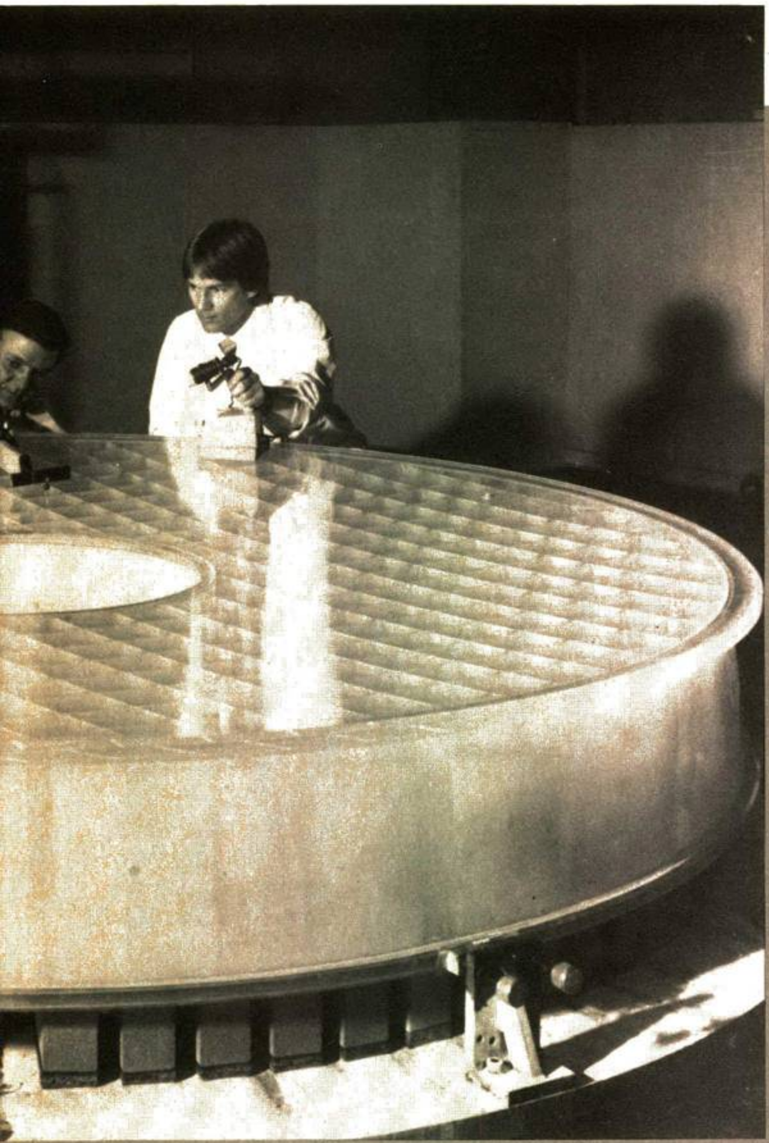
This presented the members of the optical team with an incredible challenge, for most large telescope mirrors are good to only about 1 wave. Although we tend to think of astronomical telescopes as high-precision instruments, it would be foolish to spend a lot of money to build an instrument that would give an image many times better than the Earth's atmosphere permits. So astronomers have not wasted their money. Only with the advent of space telescopes have ultra-precise optics made scientific and economic sense.

To achieve 1/20-wave accuracy for the entire telescope, the surfaces of the mirrors had to be much better than that. Terence Facey, a member of the team that determined just how good each mirror would have to be, explains: "Basically, the telescope is two mirrors, a primary and a secondary. Just to start, you give half of the error budget to the primary mirror and half to the secondary mirror. Neither can actually have half because there are some other contributors to error, such as the accuracy of the optical control system that will align the telescope in orbit and the thermal stability which, although it is very good, is going to consume some part of the error budget. So neither can really have a full 50%. But suppose we assign half of the error to the primary mirror. It's then got to be 1/40-wave, and since the light from a star hits the primary mirror and bounces off it, every error is doubled in the image. In just two very quick steps we have deduced that the surface quality of the mirror has to be at least 1/80-wave. The same is true for the secondary mirror."

Actually, the team specified the secondary as 1/110-wave and the primary at 1/65-wave in their coated and mounted configuration, skewing the assignment of allowable errors toward the primary because the secondary would be easier to make. Although the secondary is convex, which is more difficult to figure than a concave mirror, its 12.5-inch diameter would make it a lot less expensive. In fact, the opticians decided to make three secondary mirrors, then select the best one for use in the telescope.

When the primary disk was received from Corning, it was moved to Perkin-Elmer's grinding facility at Wilton, Connecticut. There the disk was edged and beveled, a central hole was bored into it, and the front and back surfaces were ground spherical. During this operation, about 200 pounds of glass was removed by a mechanical grinder fitted with a large diamond tool.

The next step, polishing and figuring the primary,



The Space Telescope's 94-inch primary mirror was constructed from two 1-inch thick sheets, one on the front of the mirror disk and one on the back, with a 12-inch thick honeycomb structure separating and supporting them. All components of the primary mirror were made from Corning's Ultra Low Expansion glass.

required extraordinary care. Because HST will operate in a weightless environment but its mirrors will be made here on Earth, the primary mirror couldn't simply be put on a machine and polished since the pull of terrestrial gravity makes even the most rigid mirror sag under its own weight. With error tolerances as small as those for the HST primary mirror, the gravitational sag creates an enormous source of error. If the mirror were supported at its edge in three places, the center would sag 17 waves — a thousand times more than the allowable error for the mirror (1/65-wave). Just suppose that the opticians shaped the mirror while it was bent this way. Once the finished mirror was sent into orbit — into a weightless environment — the mirror would spring back to its undeformed shape and become useless. The mirror had to be polished in the same zero-gravity environment it would experience in orbit.

How can you fake zero gravity with a one-ton mirror? The approach taken was to build a support mechanism of 138 rods with each rod exerting a precisely known force on the back surface of the mirror. Each rod simulated zero gravity in a small area of the mirror by off-loading a local region of the mirror by exactly its own weight. The sum of all the upward forces exactly equaled the weight of the mirror, thereby negating the downward pull of gravity.

"It's really simple engineering," says Robert Jones, then Perkin-Elmer's chief engineer for the Space Telescope. "What is sophisticated is that a lot of trouble was taken to get rid of all the secondary effects — things like friction in the counterweight pivots, errors in setting the counterweights and in the position of the rods on the mirror, variations in the thickness of the glass and in the stiffness of the mirror due to lack of uniformity in the glass. It is the degree of accuracy that we needed that made all the difference."

About 50 engineers worked for three years to build the zero-gravity simulator. They created an environment that differed from the orbital environment by, they believe, less than 1/300th wave of distortion. The force exerted by each rod was calculated with a computer from a structural model of the mirror and from measurements of the thickness of the glass taken at numerous locations over the mirror. Edge effects had to be accounted for in addition to non-uniform glass thickness. Each force was different,

"Constraining a soap bubble at six points but not deforming it in any way."

and each was optimized to support the mirror as closely as possible to what it would experience in orbit.

With the mirror resting on its zero-gravity simulator, the polishing team used a mechanical polisher to generate first a spherical surface and then a hyperboloidal surface. At this point, the mirror was about as good as that of a typical ground-based telescope — 1 wave. For the Space Telescope, the opticians hoped to make a surface at least 65 times more accurate.

The conventional method for shaping a mirror — or "figuring it," in optical trade jargon — is to use a small polishing tool to take off a small amount of glass. A larger tool is then used to smooth the area. This process is repeated until the desired figure is attained. The polishing team considered this technique but concluded that they might exceed the error budget if they used it, since the procedure also creates ripples within the overall curve of the mirror.

They turned, instead, to a computer-controlled polisher, a machine that uses a polishing tool several inches in diameter. Over a polishing run lasting a day or two, the tool polishes the entire mirror surface as the computer commands the polishing head to spend more time working on high spots than on other areas. This strategy reduces a bump substantially. If the bump still remains on the next cycle, it can be substantially reduced again. The goal is to never go too far on any single cycle since glass can't be put back on the mirror.

A feature of the HST primary mirror that tends to be overlooked when people compare it to large ground-based mirrors is smoothness. The Space Telescope's mirror was precisely specified for overall figure (the hyperboloidal shape), for ripples about one inch from crest to crest (mid-frequency), and for undulations of a small fraction of an inch (high-frequency). Bud Rigby, manager of the figuring team, explains: "Historically, mirrors have not been characterized for errors that have high frequency. In the case of Space Telescope, figure was just one measure of merit. There was also the need to measure the mirror in what we call the mid-frequency and in the pico domain where the ripples measure about 1/20-inch or less. We made special measurements to test and control these frequencies. The presence of little ripples destroys your resolution and clouds your image."

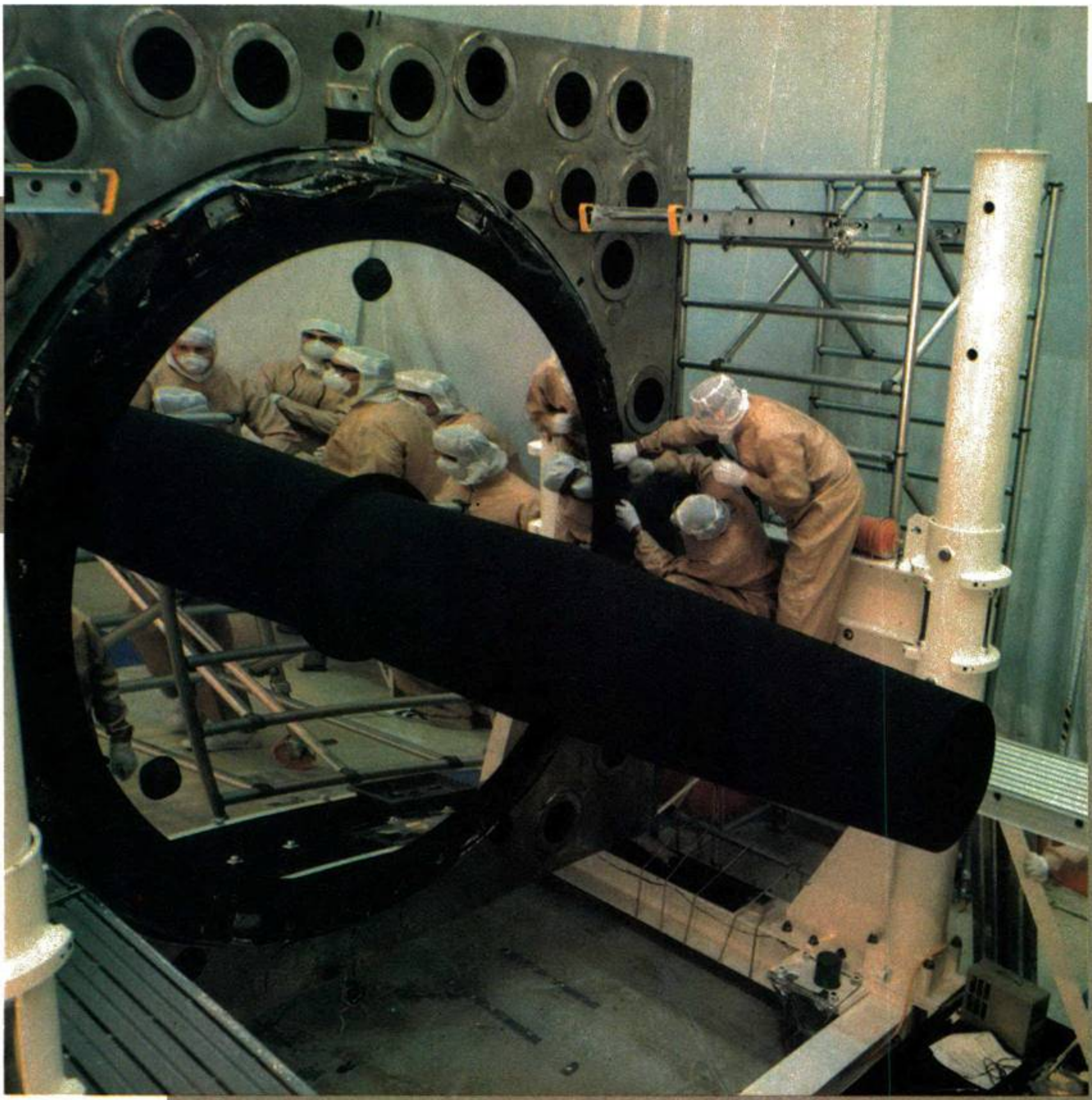
After each polishing run, the surface of the mirror was repeatedly measured with a laser interferometer, data was fed into the computer to average out any systematic errors in the measurement process, and a contour map of the surface was constructed. Using the contour map, opticians specified a new polishing program that instructed the tool where to spend more time on the next run.

A total of 25 cycles were required to figure the mirror, each cycle taking about a week. At the end of their labor, the team had produced a mirror accurate to better than 1/90-wave. It is the most precise large mirror in the world, and no hand polishing whatever was done on the mirror surface. The secondary mirror was equally demanding to figure and test, requiring another zero-gravity simulator and laser interferometer. When polishing was completed in May 1981, the secondary's quality exceeded 1/100-wave.

The next step was to coat the surface of the primary mirror. A telescope mirror is made of glass, which is relatively easy to figure but reflects very little light. Consequently, the glass is placed in a high-vacuum chamber where metal, usually aluminum, is deposited on the surface, giving the mirror its reflective surface. In the 1960s, NASA discovered that coatings had to be put on very quickly, under very high vacuum, with precise control to get good reflection in the far ultraviolet — a key spectral region that astronomers want to investigate using the Space Telescope.

With that experience in mind, the coating team began its work in November 1977. For the first few months, the practical meaning of the requirements were analyzed. The specs were easy to understand: the coating had to reflect at least 85% of visible light and 70% of far ultraviolet. It also had to be uniform to within 3% across the aperture. This meant the team had to place a layer of aluminum 2.5 microinches thick (a microinch is one millionth of an inch) over the entire eight-foot surface of the mirror, followed immediately with a one-microinch-thick layer of magnesium fluoride. The magnesium fluoride prevents the aluminum from oxidizing and enhances its ultraviolet reflectivity. It was a very difficult assignment.

In their analysis, the coating team uncovered some options they felt NASA should consider. Their research suggested that easing the uniformity requirement (ground-based telescope mirrors typically allow a 10% variation) would make a substantial difference in cost and difficulty. Moreover, the team pointed out that lowering the reflectivity requirement for the far ultraviolet would make



Ten feet long, the Cassegrain baffle is mated to the primary mirror support. The primary is already mounted in its main support ring, and that in turn is held by the large, square tooling structure. The baffle keeps stray light from reaching the science instruments.

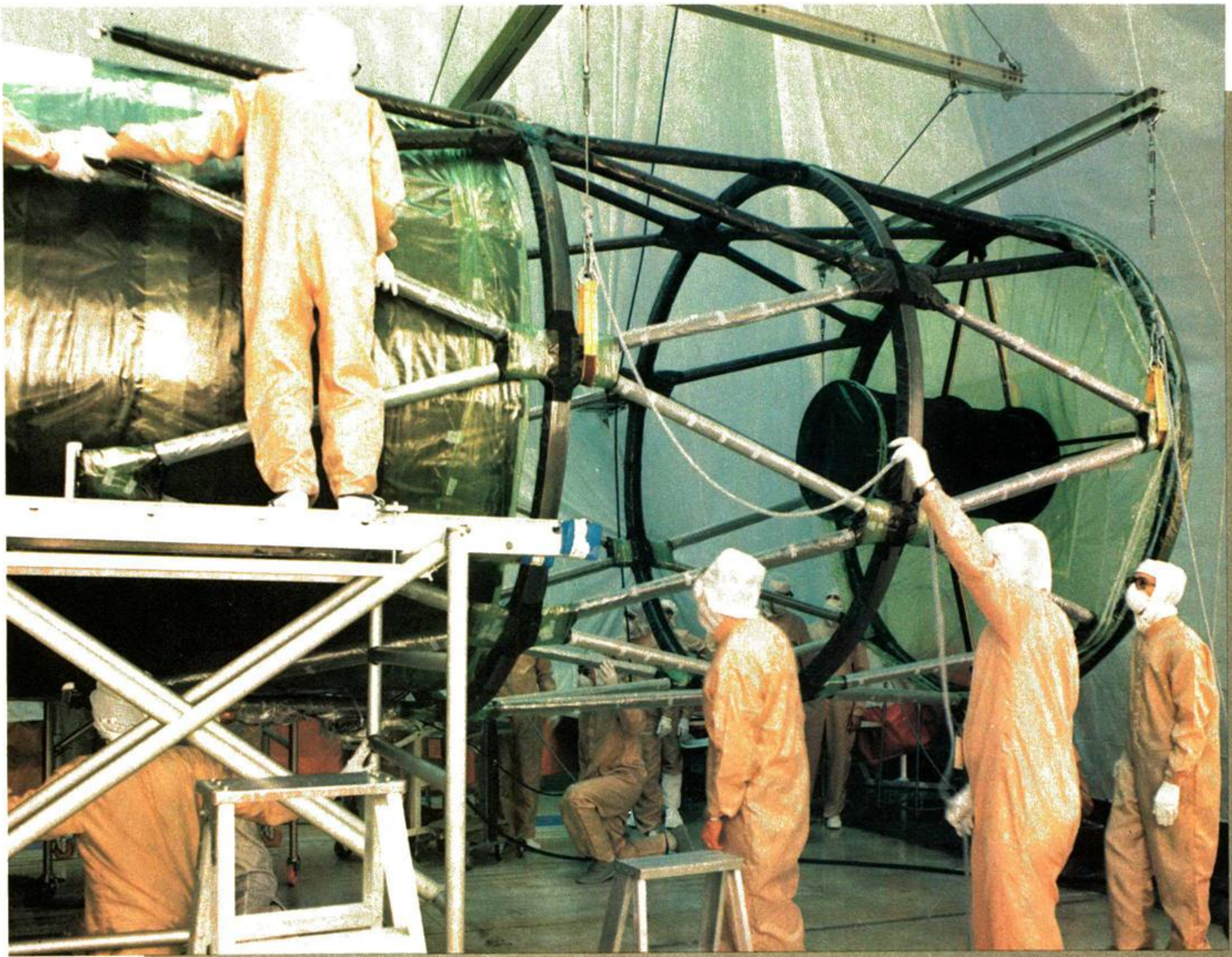
the job much simpler. By March 1978, however, NASA decided its specifications could not be relaxed: the astronomers were not willing to give up any photons in the ultraviolet.

The standard procedure for putting down an aluminum coating that operates well in the ultraviolet is to condense pure aluminum on a mirror at a rate of one microinch per second. To meet the uniformity requirement, the primary mirror would have to be spun at a high velocity inside the coating chamber while being coated. This, the coating team felt, posed considerable risk to the mirror. After a lot of study, they concluded that a better way would have to be found. The procedure settled on called for making a better vacuum in the coating chamber. This would permit reducing the deposition rate, though it would make pumping out the coating chamber far more difficult.

Another hurdle that the coating team faced was cleaning the mirror before coating it. They proposed a machine with rotating arms, but it took a long time to convince the project managers that such a machine was the safest, most feasible approach. The cleaning took five days and consumed 2,400 gallons of hot, deionized water.

The day set to coat the primary mirror was December 5, 1981. After hundreds of preparatory tasks had been completed, the mirror was placed in the coating chamber and slowly heated to 250° F. Only a few nerve-wracking hours remained. A final cleaning, using glow discharge in the chamber, removed any traces of organic contamination that could spoil the coating. The team watched and waited, making certain that the coating chamber's pressure and temperature were "on the money" for depositing the coatings.

When the mirror temperature fell a bit around noon,



To insure that the Hubble Space Telescope stays in focus, the primary and secondary mirrors are supported by the 200-inch-long graphite-epoxy metering truss. Graphite-epoxy is light, strong, and, most importantly, it expands or contracts very little with temperature changes. The distance between the two mirrors must remain fixed within 1/10,000th of an inch!

the team decide to break for a pizza while the problem was corrected. By 12:30, there wasn't a sound in the lunch room, although there were 15 people in it. "I started to get nervous," team leader Jack Kurdock remembers. "I told everybody that we had plenty of time and we didn't want any mistakes. I didn't want anyone reacting to a problem. They should just report a problem."

At 1:15, the coating sequence began. Under computer control, four aluminum beam guns switched on and stepped up to their combined power of 48,000 watts. Then the shutters located between the rotating mirror suspended from the top of the chamber and the guns positioned on the bottom opened. Aluminum was deposited on the mirror and things looked good. As the aluminum guns shut down and the magnesium fluoride guns came up to full power, however, the control panel flashed that one gun was not operating at full power. The computer automatically held the shutters closed, preventing the magnesium fluoride from being deposited on the aluminum.

On everyone's mind was the question: What now?

A spotter wearing welding glasses looked into the chamber and reported that the gun appeared to be operating correctly, even though the control panel indicated that its evaporation rate was low. The team decided to watch a little longer, hoping the gun would come up to full power. After holding for 68 seconds, they decided to go with three guns and boost the evaporation rates. To everyone's surprise, all four guns worked perfectly when the shutters opened and the magnesium fluoride was deposited.

Subsequent tests established that the coating team had achieved success. After four years of preparation, they had flawlessly coated the mirror in four minutes and had even

"The task of the truss is all the more awesome when one realizes that astronomers plan to observe faint targets for long periods of time."

given NASA 11% more photons in the far ultraviolet than specifications called for.

With the mirrors figured and coated, the spotlight turned to the telescope assembly team. Ideally, HST's mirrors should float free of stresses, with no more than a few tiny clips to hold it in place. This is not possible, though, because when it is launched aboard the Space Shuttle, the entire Space Telescope and its one-ton primary mirror will be subjected to heavy acceleration — up to three gees. The Space Shuttle also subjects its payload to heavy vibration, especially as the liquid-fuel main engines and the solid-fuel booster rockets begin to burn. The ride into space demands a much more rigid structure than is required for the construction (at one gee) or operation (at zero gee) of the telescope.

But the mirror could not simply be placed in its mount and the bolts socked up good and tight, for such a procedure would lock in the mirror's gravity-induced sag. Once in orbit, these forces would disfigure the beautiful mirror that the figuring and coating teams had labored to create.

The assembly team began their work by putting the mirror back on the zero-gravity simulator. It was remeasured and found to have dropped in quality to 1/85-wave. This was expected since some loss of quality is routine in the coating process. The team took this number as their quality baseline.

The first step was to place the mirror mount — the box beam structure that holds the mirror in the telescope — on a zero-gravity simulator of its own so that it, too, would be free of self-deflection stresses. The mirror was suspended within the mount, restrained by stainless steel tubes at six points.

The mount is hardly delicate instrument hardware — it must hold the mirror firmly during launch — but its hold on the mirror had to be exquisitely delicate. Each time the team added another piece to the mirror support, they had to recalculate the forces in all 138 support rods to recover zero gravity. "Constraining a soap bubble at six points but not deforming it in any way" was how William Raiford, the leader of the assembly team, viewed their objective. Their job consisted of adding a little piece of hardware, recalculating the force distribution to recover zero gravity, then measuring the mirror with the interferometer to verify that no mistakes had been made. If the team goofed, the mirror told them.

Mounting took one and one-half years. When it was completed in May 1983, the team checked the mirror one last time and found it to be 1/70-wave — still within the specification of 1/65-wave!

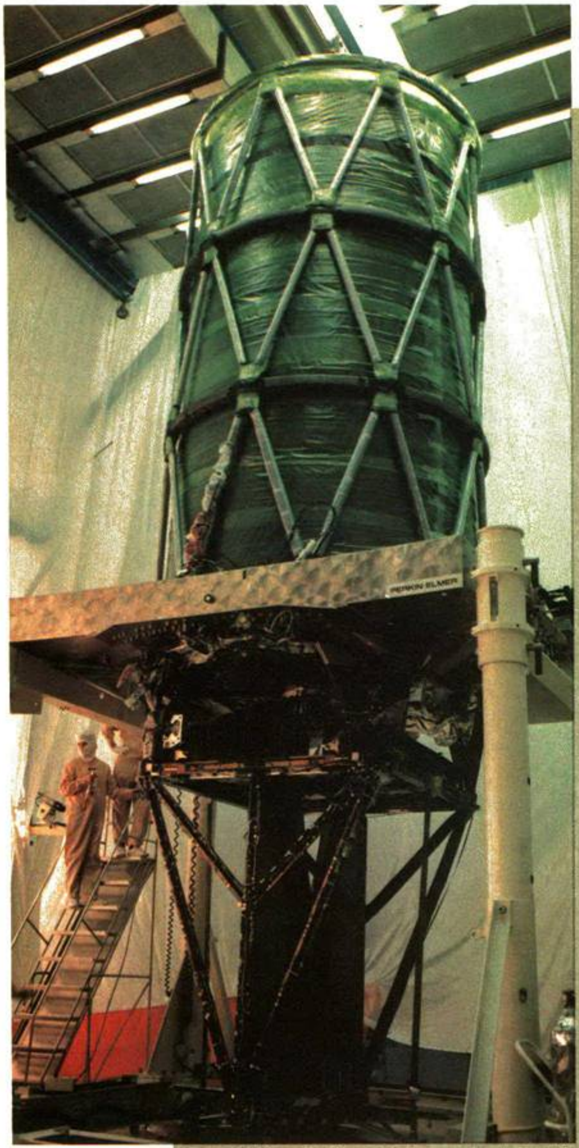
"Most of the work on a project like the Space Telescope is thousands and thousands of hours of detailed analysis of problems, figuring out if you can do something, doing it, making sure it meets the error budget, certifying it, and going on to the next challenge," Robert Jones comments. "It is thousands of decisions that overcome a myriad of little difficulties which, if allowed to remain, would add up to enough slippage and imperfection to defeat the image quality the astronomers need."

If the optical system were to operate in an unchanging environment, the structural stability of the telescope would not be a particular concern. However, the Space Telescope will be in a very unstable environment as it circles the Earth once every 100 minutes, experiencing a boiling-hot "day" and a freezing-cold "night" on each orbit. Under such conditions, existing materials would undergo thermal expansion and contraction. A mirror truss, the structure that maintains the 65-pound secondary mirror in precise alignment with the primary mirror, made from standard materials would put the Space Telescope perpetually out of focus. A new type of material was needed.

In the early 70s, NASA funded research on a new material composed of graphite-fiber-reinforced epoxy. It held great promise for making strong, lightweight structures that were highly stable over a wide temperature range. By the mid-70s, graphite epoxy had been proven just the right stuff to hold HST's mirrors.

The Boeing Aircraft Company fabricated the Space Telescope's metering truss; it was delivered in the fall of 1980. The truss measures 210 inches long and 115 inches in diameter but weighs a mere 252 pounds. In contrast, the tube of the 200-inch Hale telescope is 60 feet long and weighs 120 tons. Despite temperature changes of more than 280° F in space, the truss will not change its length by more than 118 microinches!

The metering truss controls three kinds of potential movement: despace, a change in the distance between the mirrors that particularly defocuses faint images; decentering, a lateral movement such that the primary and secondary mirror optical axes, though parallel, are no longer coincident thus causing image smear; and tilt, an



The Optical Telescope Assembly rests on its final assembly stand. The metering truss is clearly visible above the large, square tooling structure. The Space Telescope science instruments will be mounted on the truss at the lower end of the telescope.

angling of the optical axes which also smears images. The error allowance for despace is only 40 microinches, which the truss must maintain.

The task of the truss is all the more awesome when one realizes that astronomers plan to observe faint targets for long periods of time. Pointing precisely at a target for as long as 24 hours may yield only 10 hours of actual observing time due to interference from bright sources like the Sun, Moon, and Earth.

Before bolting the truss onto the mirror mount, the assembly team attached six tiny motorized actuators to the top of the truss. Each actuator can be moved one microinch at a time. They will be used to focus the telescope several times during the first month in orbit and whenever necessary after that. Graphite epoxy is hygroscopic, so although the truss was stored in air containing less than 50% relative humidity, it nonetheless absorbed almost a pound of water. Over the first few weeks in orbit, the water will evaporate and the truss will contract by some 8,000 microinches. But the truss will also expand, by a lesser amount, as it emerges from Earth's gravitational field. The assembly team calculated these changes and built the difference into the alignment of the secondary mirror. If their calculations are accurate, the telescope will be perfectly focused when the truss dries out in orbit. Until that time, however, the actuators will be used to focus the telescope.

To provide added assurance that the Space Telescope's images will be superlative, the assembly team covered the back and sides of the primary and secondary mirrors with small heaters about the size of a matchbook. These heaters will maintain the temperature of the mirrors within one degree of 70° F. This will not only minimize figure distortion due to expansion and contraction, but it will also prevent contaminating gases from sticking to the mirrors' surfaces, which would happen if they were cold. In total, some 700 heaters were bonded to the mirrors, the mirror truss, and the frame that holds the scientific instruments in place behind the primary mirror.

A major technical achievement of the HST optical program is the design of an alignment system that enables ground controllers to adjust the position of the secondary mirror and the alignment of the primary mirror while in orbit. This will be done using data telemetered to the ground from three interferometers located at the focal plane of the telescope.

Another unique part of the optical alignment system allows ground controllers to refigure the mirror. Behind the primary is an aluminum plate to which 24 rods are attached that individually connect to the primary mirror. These are capable of bending the surface of the primary mirror about 1 wave to correct broad distortions in its figure. This system is not one which NASA expects to use, but it does provide insurance.

On October 29, 1984, Perkin-Elmer completed the optical system. Scheduled for launch in late 1986, the Hubble Space Telescope will soon begin to revolutionize optical astronomy. The firm has devoted seven years and four million man-hours to "the most challenging and demanding" space science project it has ever undertaken. A member of the optical team captured the feelings of all who worked on the project when he said quietly, "I kept myself going by thinking about those first images five days after launch!"

Gary Watson is a professor of business law at Cal State, Los Angeles, whose interests include science, technology, and the law. He became intrigued by the Space Telescope while researching current trends in large-scale science.

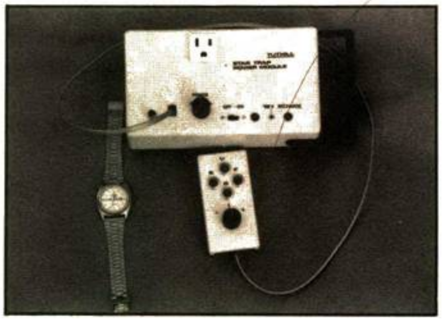
YOUR ASTRONOMICAL FRIEND IS RATHER PROUD OF MORE THAN A DECADE OF INNOVATIONS BENEFITING AMATEUR ASTRONOMERS

The Tuthill Co. has pioneered and developed more innovative, time saving, valuable, and useful telescope accessories than all other manufacturers combined. Look at this record of thirteen years of engineering effort to create products designed to make amateur astronomy into a more fun hobby:

- **1973 The Solar Skreen®** A SAFE, high-resolution, low-cost Sun filter. The ONLY broad-band Sun filter covered by a USA Patent — #3,897,140.
- **1973 The Luna Shade.** A high-resolution, low-cost, full aperture Moon filter.
- **1974 The Star Trap® Rich Field 4½″ hand-held telescope.** A precursor to the Astro Scan®
- **1975 The Astro Tule.** A novel SLR camera image plane focusing tool for all astrophotographers.
- **1975 Large 50m and 80mm right angle/straight thru finders** with 1¼″ focusable eyepieces with Ring-O-Fire glow-in-the-dark rustproof cross hairs.
- **1976 The Tuthill Camera Drive.** A tripod-mounted 1-, 2-, or 3-Camera unit for either hemisphere.
- **1976 The Solar Prominence Probe.** A low cost Hydrogen Alpha filter for the Sun.
- **1976 Azimuth and Elevation adjustments** and **No-Tool-Knob sets** for SCT wedges.
- **1977 The StereOOcular®** A large prism binocular eyepiece mount for spectacular views of the Moon and planets with 1¼″ eyepieces.
- **1978 Heated No Du Caps** for inhibiting corrector plate dewing on SCT scopes.
- **1979 The Precision Polar Axis Finder.** A novel patented aligning tool allowing the beginner to find the true North Celestial Pole accurately, quickly and easily — USA Patent #4,260,253.
- **1980 Celestial Navigator® Mark I.** A digital readout of RA and Dec circles for amateur scopes.
- **1981 The Celestial Navigator® Mark II.** The FIRST commercial application of computer control for amateur telescopes.
- **1982 The Isostatic Equatorial Mount.** A sturdy, rugged, vibration-free redwood and aluminum combination wedge and tripod for SCT scopes.

And now 1986 — *One of the most useful accessories of all.* **The Star Trap Power Module®** A rechargeable battery, inverter, and drive corrector all rolled into one small, lightweight, portable package.

Send a Large Self-Addressed Stamped (3 oz.) Envelope to find out more about these great products.



MODEL #1
Star Trap Power Module®
Drive Corrector

Recognized as Headquarters For
Solar-Skreen® Sun Filters

Send a large (9″ x 12″ — 3 oz.) MANILA Self-Addressed Stamped Envelope for our Complete Information Kit including "Tuthill's Twenty-Two Telescope Tips."

P.S. WE ALSO SELL TELESCOPES!!

MasterCard VISA

ROGER W. TUTHILL, INC.

Telephone: 1-800-223-1063 / in NJ call (201) 232-1786
11 Tanglewood Lane, Dept. A, Mountainside, NJ 07092

ASTRONOMY Forum

The Main Sequence Blues

Once upon a time there was a five-solar-mass star named Brutus. This five-solar-mass star was the biggest, meanest five-solar-mass star in the whole spiral arm. Now, the latest fad in Brutus' stellar neighborhood was to get an energy high by burning hydrogen in your core (where no one could see you do it). At night, when few people were looking, Brutus and his buddies would line up on the Hertzsprung-Russell Diagram and "do" hydrogen. They called themselves the Main Sequence.

Now Brutus could party up a storm: he could "do" more hydrogen than his smaller friends and was frequently seen even in the wee hours of the morning all energized up, spitting out photons like crazy.

Soon Brutus burned all his core hydrogen and the law demanded that he leave his friends on the Main Sequence and go off to galactic prison. There Brutus was first assigned to the Red Giant Branch, where he met up with some hard core types. His old friends thought this was just a phase he was going through and that he would be back soon, but for Brutus there was no return.

"Hey man, do HELIUM, man," his big new friends would say. "You'll reach a new high. Do it, man, do HELIUM." Since all his 'Giant buddies were into helium, so, eventually, was Brutus. He became more energetic than ever before. But before Brutus expected it, he burned out, he ran out of helium to burn in his core. Brutus became depressed and contracted within himself.

"Hey man, do CARBON, man," some of the cooler stars would say. "It'll blow your mind, it'll dump your depression, it'll ignite your innards. Don't be a dwarf star, man, DO it!"

So Brutus did carbon, and it was even more fantastic than they said — it was the best of any element yet. The photons pulsed through Brutus' photosphere like never before in his entire life. But after almost no time, his carbon burned out and none of the other stars would sell him theirs — not even his down-and-out white dwarf friends. The only thing Brutus could do was burn carbon around his core, which he did. He did helium and hydrogen as well, but it just didn't turn him on like it used to. Brutus needed something else.

"Should I do SILICON, man, should I?" he asked his friends.

"That degenerate stuff? Are you crazy? I wouldn't touch that stuff. No way. Uh-uh," they all said. "Just cool out, okay?"

"You can't do it, you're not big enough," his smart friends would say. "It's 'da body weight, you don't have enough, so stay off the silicon, man. Stay off the silicon, you hear?"

But Brutus wouldn't listen. When nobody was looking, he tried to do silicon.

One day, one of Brutus' old flames came by the old stellar neighborhood asking about him. "Whatever happened to that big hunk of gas?" she asked.

"Oh look, THERE he is," some star replied, indicating a super bright flare in the sky that slowly faded to nothing. Even stars that knew Brutus were shocked.

"Too bad," she said, "he never did know his limitations."

"Nonsense," Brutus' friends disagreed, "it was fate."

But on one thing they did agree: the answer was blowing in the wind.

— *Robert J. Nemiroff*
Dept. of Astronomy & Astrophysics
University of Pennsylvania
Philadelphia, PA

Stalking An Asteroid's Shadow

"The mosquitoes were gnawing through the repellent on faces and hands. Dew was forming on the equipment. A pack of wild dogs was howling in the brush a few hundred yards across the tarmac. At observing station #4, an ominous bank of clouds slowly drifted in from the southeast. The next few seconds would determine whether our 750-mile island-hopping venture into the Caribbean had paid off: we'd get about 75 seconds of excitement as the seventh-magnitude asteroid Ceres occulted a 10th-magnitude star named BD +8° 471 in Cetus."

That is how one observer described the culmination of an expedition that began in the pre-dawn twilight of November 12, 1984. On that date, three teams of observers from the Florida Institute of Technology (FIT) and the Massachusetts Institute of Technology (MIT) boarded a chartered aircraft in Melbourne, Florida, that would deploy them to separate islands in the Bahamas and the West Indies. Two other teams were stationed at the FIT Observatory in Melbourne and in the Florida Keys. The sites were chosen to cover the entire expected 600-mile diameter of Ceres' shadow as it passed through Florida and the Caribbean.

Why such a major effort? Because occultations provide the most accurate means of measuring the diameter of asteroids like Ceres. The physical dimensions of asteroids are generally too small to obtain by direct imaging

(Publishers' Prices shown.)

Take Any 3 Books for $1.00 Each!

Values to $59.85

as your introduction to the

Astronomy Book Club.

You simply agree to buy 3 more books—at handsome discounts—within the next 12 months.

UNIVERSE GUIDE TO STARS AND PLANETS
Ian Ridpath · Wil Tirion
THE CAMBRIDGE ATLAS OF ASTRONOMY
THE EXPLODING SUNS
ISAAC ASIMOV
NIGHTWATCH
AN EQUINOX GUIDE TO VIEWING THE UNIVERSE
HOW TO USE AN ASTRONOMICAL TELESCOPE
JAMES MUIRDEN
NEMESIS
The Death Star and Other Theories of Mass Extinction
Donald Goldsmith
CELESTIAL MECHANICS
A Computational Guide for the Practitioner
Laurence G. Taff
THE NEW ATLAS OF THE UNIVERSE
PATRICK MOORE
The Cambridge Deep-Sky Album
Celestial BASIC
Eric Burgess
Astronomy On Your Computer
THE LIFE & DEATH OF STARS
by Donald A. Cooke
Webb Society Deep-Sky Observer's Handbook
Numerical Astrophysics
Centrella
LeBlanc
Bowers
The Mystery of COMETS
Fred L. Whipple
THE SOUL OF THE NIGHT
An Astronomical Pilgrimage
CHET RAYMO
A WORKBOOK FOR ASTRONOMY
JERRY WAXMAN
STANDARD HANDBOOK FOR TELESCOPE MAKING
International Halley Watch Amateur Observers' Manual for Scientific Comet Studies
PRACTICAL ASTRONOMY WITH YOUR CALCULATOR
SECOND EDITION
PETER DUFFETT-SMITH
Masks of the Universe
Edward Harrison
RINGS:
Discoveries From Galileo to Voyager
THE HIDDEN UNIVERSE
BURNHAM'S CELESTIAL HANDBOOK
observational astronomy for amateurs
Fourth Edition
by
J.B. Sidgwick
Completely revised by James Muirden
THE MOMENT OF CREATION
Big Bang Physics
James S. Trefil

85358 $19.95
37201-3 $75.00 (Counts as 3 choices)
47175 $18.95
64709 $19.95 (Spiralbound)
53910-2 $21.95 (Counts as 2 choices)
63980 $15.95
37398-3 $45.00 (Counts as 3 choices)
64156-2 $40.00 (Counts as 2 choices)
37205 $19.95
37395 $16.95 (Softbound)
58387-2 $29.95 (Counts as 2 choices)
86605-3 $64.75 (Counts as 3 choices) (Softbound)
64912-3 $65.00 (Counts as 3 choices)
63375-2 $24.95 (Counts as 2 choices)
79290 $15.95
87510 $19.95 (Spiralbound)
80156 $15.95
55956 $9.95 (Softbound)
69739 $11.95 (Combbound)
60600 $18.95
74210 $17.50
52800 $16.95
36978-3 $60.00 (Counts as 3 choices)
65185 $19.95
62913 $15.95

4 Good Reasons to Join

1. **The Finest Books.** Of the hundreds of books submitted to us each year, only the very finest are selected and offered. Moreover, our books are always of equal quality to publishers' editions, *never* economy editions.

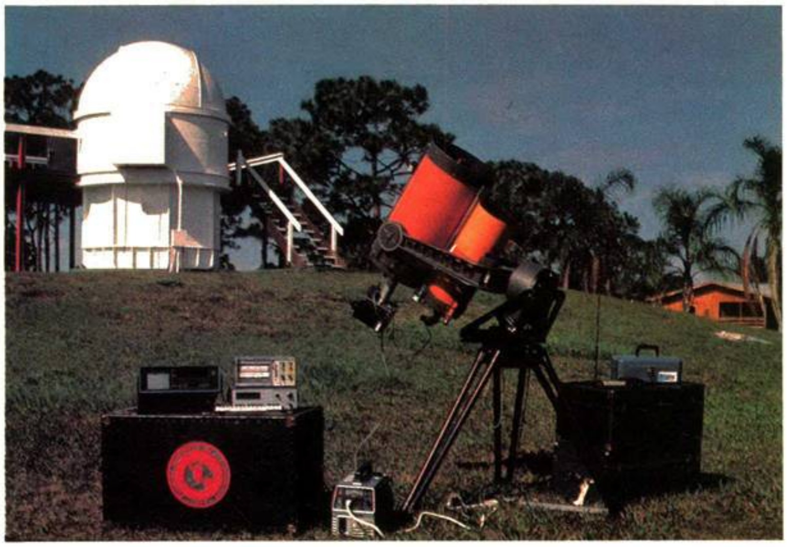
2. **Big Savings.** In addition to getting 3 books for $1.00 each when you join, you keep saving substantially, up to 30% and occasionally even more. (For example, your total savings as a trial member, including this introductory offer, can easily be over 50%. That's like getting every other book free!)

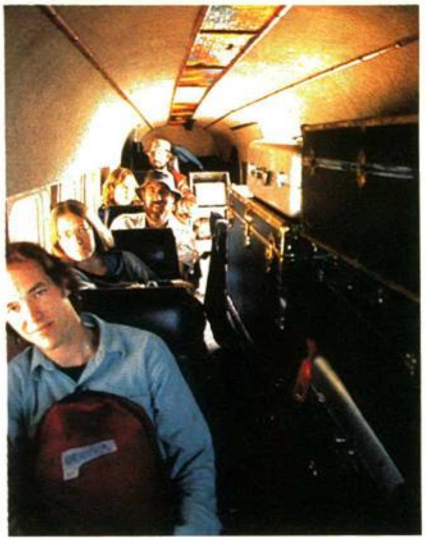
3. **Bonus Books.** Also, you will immediately become eligible to participate in our Bonus Book Plan, with savings up to 70% off the publishers' prices.

4. **Convenient Service.** At 3–4 week intervals (16 times per year), you will receive the Astronomy Book Club News, describing the Main Selection and Alternate Selections, together with a dated reply card. If you want the Main Selection, do nothing, and it will be sent to you automatically. If you prefer another selection, or no book at all, simply indicate your choice on the card and return it by the date specified. You will have at least 10 days to decide. If, because of late mail delivery of the News, you should receive a book you do not want, we guarantee return postage.

If the reply card has been removed, please write to **Astronomy Book Club, Dept. L-BL5, Riverside, N.J. 08075** to obtain membership information and an application.

Astronomy 1/86





The basic equipment needed to track an asteroid's shadow is a portable occultation photometry system (left), shown outside the Florida Institute of Technology's observatory. Three teams of observers and their photometry equipment (below) get comfortable aboard the plane that will take them island-hopping through the West Indies in search of asteroid Ceres' shadow. Photos by Terry Oswalt.

from Earth. In the last several years, however, the orbital parameters of many asteroids and the fundamental positions of stars have been refined to such an extent that the passage of an asteroid in front of a fixed background star can be predicted several months in advance. In such an event, the ground-based observer sees the star occulted (eclipsed) for a time interval that is directly related to the length of a single chord across the face of the occulting asteroid. The "shadow" of the asteroid is roughly the width of the asteroid itself. The duration of such an event is usually a matter of seconds, so even a single errant cloud can ruin a station's observations. In order to accurately determine the shape of the asteroid, observers must be well-distributed across the width of its occultation track.

The most accurate way of timing an asteroid occultation is to observe the event photoelectrically while simultaneously recording the time signals from shortwave radio station WWV. This produces a photoelectric record of the combined light of the asteroid and star, which drops abruptly (ingress) as the star is occulted, leaving only light from the asteroid. This is followed by an equally abrupt increase in light (egress) as the star reappears. Roughly speaking, the time interval between ingress and egress multiplied by the speed of the asteroid's shadow across Earth's surface gives the length of a single chord across the asteroid's disk.

Three chord measurements are required if the profile of the asteroid is elliptical, as is typical of large asteroids like Ceres. The uncertainty involved in predicting the exact path of the occultation, however, usually requires at least five stations to assure that three chords will be obtained.

About two years ago, an occultation-timing program was organized among the student members of the FIT Astronomy Society (FITAS). We now have over two dozen observers, mostly undergraduate space science majors, who have visually timed one or more asteroid occultations since the Pallas-1 Vulpecula occultation in May 1983.

The November 13, 1984 occultation of the star BD +8° 471 by Ceres was particularly attractive to us. The prediction published by Millis, *et al.* (*Astronomical Journal*, May 1984, p. 698), was made sufficiently early that a major effort could be planned. FIT had a significant geographical advantage over other potential observers: the preliminary ground track of this occultation passed through Florida and the Caribbean, its width roughly spanning the distance between central Florida and Haiti.

The Ceres occultation presented the FIT observers with one major problem, however. During the event, only a five percent drop in light would occur as BD +8° 471 was occulted by the much brighter Ceres. This was much less than our visual observers could detect. At the time, we only had a non-portable photometry system and several Celestron telescopes at the FIT Observatory. However, the recent decline in the cost of microcomputers and photoelectric equipment has made it financially possible for serious amateurs and small schools like ours to construct a portable occultation photometry system from "off-the-shelf" equipment.

The system assembled at FIT consisted of just four major components: a Celestron 14-inch telescope with tripod and C-8 guidescope, a Thorn-EMI Gencom Starlight-1 photoelectric photometer, a Commodore SX-64 portable computer with integral monitor and disk drive, and a Honda portable generator. The computer reads the counter on the photometer about 20 times per second and fills the available memory in just under 15 minutes. Data can then be dumped to a floppy disk after the event.

Even if the FIT Observatory fell within the northern edge of the occultation, two photoelectric stations would be enough only if Ceres turned out to have a circular profile. MIT, having three portable systems, was in a similar situation since four or five stations would have to be deployed to guarantee acquiring at least three chords. A joint effort was the obvious solution.

The tried and true "drive like mad and set up at the last minute" tactic normally used by asteroid occultation observers to avoid inclement weather was clearly impossible for the Caribbean part of the occultation track. We chose to use a chartered aircraft, a tactic euphemistically dubbed the "tropical vacation."

The choice of observing sites was not easy. The safety of observers who would be abandoned overnight could not be guaranteed on islands where illegal drug traffic had been reported, nor could the possibility of aircraft theft in such areas be ignored. In addition, customs arrangements for island-hopping individuals with scientific equipment are formidable and would be compounded by choosing sites under different governments.

NEW! Meade 2045 Schmidt-Cassegrain

4″ LIST: $995 $649

NEVER LEAVE HOME WITHOUT IT! *The* ultra-portable, full-featured astronomical telescope system (also spotting scope or telephoto lens, with appropriate accessories). Complete with compact, foam-lined metal carrying case, small enough to hand-carry onto an airplane—a real getaway special!

FACTORY-SPECIFIED STANDARD EQUIPMENT, 4″ MODEL 2045: 4.0″ aperture, 1000mm focal length, f/10 Schmidt-Cassegrain optical tube assembly, with diffraction-limited optics; high-transmission anti-reflection coatings (MgF_2) on corrector plate; ultra-smooth anti-backlash focus mechanism; anti-reflection coated diagonal prism, 1.25″; two fully-anti-reflection coated eyepieces (40x & 110x), 1.25″; 5x24mm achromatic viewfinder; ¼-20 (American std.) photo tripod mount for optical tube when dismounted; rugged dual-fork astro mount, with frequency-controlled electric tracking motor; (115VAC) and precision drive gearing built into base; graduated setting circles, manual positioning controls and brakes on both axes of motion; table-top tripod legs (adjustable for latitude); dust covers for scope's optical apertures; power cord; instruction manual; foam-lined metal carrying case for storage and transport of all equipment above; limited lifetime warranty.

NEW! Meade 6600 & 8800 Newtonians

6″ LIST: $1,100 $699

8″ LIST: $1,400 $899

The best equatorially-mounted aperture/quality/dollar value!

FACTORY-SPECIFIED STANDARD EQUIPMENT, MODELS 6600 & 8800: 6″ aperture f/5, or 8″ aperture f/4.5, Newtonian optical tube assembly (color: blue, with black trim); diffraction-limited optics; all-metal tube; 6x30mm viewfinder; 1.25″ rack-and-pinion focusser; two 1.25″ eyepieces, MA25mm (30x/6″, 37x/8″) and MA9mm (85x/6″, 102x/8″); dust caps; "Professional-Series" equatorial mount with: micrometer azimuth adjustment; micrometer latitude adjustment, with graduated latitude scale; manual positioning/tracking controls, locks & graduated setting circles on both axes; mounting clamps for optical tube assembly; quick-adjust, sliding-type counterweights; quick-disconnect counterweight shaft for easy transport; high-damping, adjustable wood tripod; accessory tray; instruction manual; limited lifetime warranty.

Optional Quartz Motor Drive System, List $220 .... **$149**

NEW! Meade 2080/LX3 MC/SO Quartz

8″ LIST: $3,020 $1,899

The ultimate combination of aperture, focal length, convenience, portability, versatility, and optical, mechanical and electronic precision and accuracy!

FACTORY-SPECIFIED STANDARD EQUIPMENT, MODEL 2080/LX3 MC/SO: 8.0″ aperture, 2000mm focal length, f/10 Schmidt-Cassegrain optical tube assembly, with certified diffraction-limited optics; multi-layer anti-reflection coatings on corrector plate, and "enhanced" (multi-layer overcoated) metal coatings on mirrors (aluminum on primary and silver on secondary); ultra-smooth anti-backlash focus mechanism; 8x50 illuminated-reticle polar-axis-type viewfinder; 1.25″ visual accessory holder; multi-coated diagonal prism, 1.25″; two multi-coated eyepieces (20mm, 100x Research-Grade Erfle; 7mm, 286x Orthoscopic), 1.25″; rugged dual-fork astro-mount, with graduated setting circles, manual positioning controls and brakes on both axes of motion; quartz microelectronic sidereal-rate drive system built into drive base, including ultra-precision LX worm-gearing; power panel (also built into drive base) with controls and connectors for various accessory/auxiliary electronic equipment; 25 ft. 115/VAC power cord; 25 ft. 12VDC power cord; piggyback camera bracket; deluxe equatorial wedge with azimuth and latitude micrometric alignment adjusters, latitude scale, bubble level, magnetic compass, and no-tool knob set; ultra-rigid adjustable-height field tripod; audio cassette instructions on set-up and applications; instruction manual; dust covers for scope's optical apertures; foam-lined carrying case for scope tube & fork-mount/drive base assembly; limited lifetime warranty.

(Photo Not Available—Appearance Identical to 2080/LX3, But Larger)

NEW! Meade 2120/LX3 MC/SO Quartz

10″ LIST: $4,790 $3,249

The maximum-aperture one-person Schmidt-Cassegrain!

FACTORY-SPECIFIED STANDARD EQUIPMENT, MODEL 2120/LX3 MC/SO: 10.0″ aperture, 2500mm focal length, f/10 Schmidt-Cassegrain optical tube assembly, with certified diffraction-limited optics; multi-layer anti-reflection coatings on corrector plate, and "enhanced" (multi-layer overcoated) metal coatings on mirrors (aluminum on primary and silver on secondary); ultra-smooth anti-backlash focus mechanism; 8x50 illuminated-reticle polar-axis-type viewfinder; 1.25″ visual accessory holder; multi-coated diagonal prism, 1.25″; two multi-coated eyepieces (20mm, 125x Research-Grade Erfle; 7mm, 357x Orthoscopic), 1.25″; rugged dual-fork astro-mount, with graduated setting circles, manual positioning controls and brakes on both axes of motion; quartz microelectronic sidereal-rate drive system built into drive base, including ultra-precision LX worm-gearing; power panel (also built into drive base) with controls and connectors for various accessory/auxiliary electronic equipment; 25 ft. 115/VAC power cord; 25 ft. 12VDC power cord; piggyback camera bracket; deluxe equatorial wedge with azimuth and latitude micrometric alignment adjusters, latitude scale, bubble level, magnetic compass, and no-tool knob set; ultra-rigid adjustable-height field tripod; audio cassette instructions on set-up and applications; instruction manual; dust covers for scope's optical apertures; foam-lined carrying case for scope tube & fork-mount/drive base assembly; limited lifetime warranty.

THESE PRICES EFFECTIVE JANUARY 2, 1986

Our Guarantee

We are exclusively, professionally, solely a telescope dealership. We guarantee, unconditionally, that when you buy a telescope from us, you will receive *all* of the equipment that its manufacturer specifies for it, and at the price specified in our ad. We do *not* "strip" scope kits. We do *not* charge extra for equipment intended by the manufacturer to be included with the scope, *nor* do we claim "typographical error" with regard to price or factory-specified equipment. Consequently, the foregoing ad contains *complete* listings of the factory-specified equipment for each of the telescopes shown, and *all* of that equipment is included in the price shown. You may rely on it!

CALIFORNIA TELESCOPE COMPANY

Authorized Meade Dealer

Free Freight, in the 48 contiguous states—except on credit card orders. Send *business-size* SASE for discount price list. U.S. sales only—Calif. shipping addresses, add sales tax. Quantities are limited.

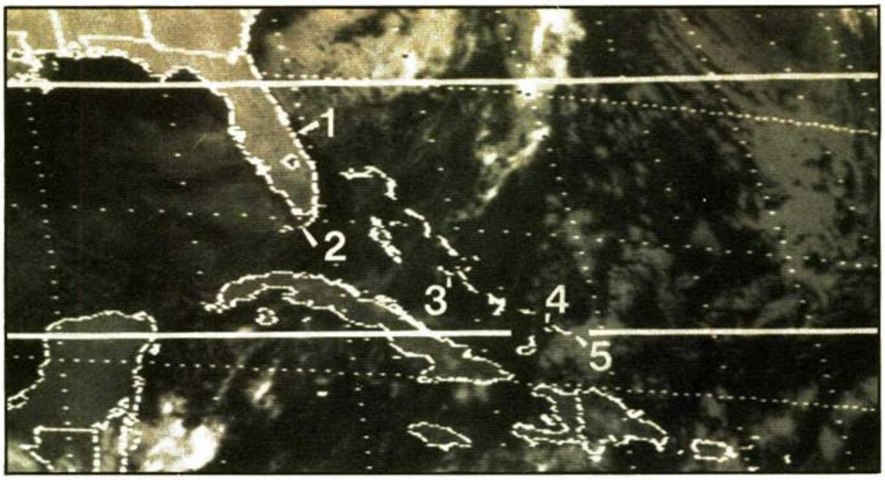
P.O. Box 1338, Burbank, California 91507

VISA

Orders only, 10-4 Pac. Time, Mon-Fri:

(818) 505-8424

The five sites chosen, shown on the map at right, are (1) FIT Observatory, Melbourne, Florida; (2) No Name Key, Florida; (3) Great Exuma Island, Bahamas; (4) Providenciales, Caicos Islands; and (5) Grand Turk Island. The three island-based stations were reached by a single aircraft.



The five observation sites are shown scattered between the northern and southern boundaries of the asteroid's shadow marked by solid white lines.

The hectic weeks before the occultation were spent testing software, firming up travel arrangements, and keeping abreast of updates in the predicted path of the occultation. Arnold Klemola at Lick Observatory and Robert Millis and Larry Wasserman at Lowell Observatory took astrometric plates of the field around BD +8° 471 as Ceres approached. About a week before the occultation, their measurements indicated that the expected track of the occultation had shifted well south of that originally predicted. For a while we considered moving several stations farther south. Fortunately, the difficulties involved in doing so led us to drop the idea.

A dress rehearsal was held at the FIT Observatory the night before our departure. The MIT observers were introduced to their FIT "observing assistants," all equipment was set up, and the star field around BD +8° 471 was studied for the last time.

The observing teams met at the Melbourne airport before dawn on November 12th in a blustery 40-degree wind. A real surprise was waiting on the runway. Our plane, a 1956 twin-engined Beechcraft, looked like the one Indiana Jones crashed in the Himalayas in the movie *Temple of Doom*. The vintage plane had an extraordinarily long nose upon which was painted a caricature and the name "Cyrano." We wondered aloud whether our 1,500 pounds of equipment and six observers would even fit in the cabin, much less meet the weight restrictions. Remarks about having to use our three C-14 telescopes as "flotation" circulated. Our pilot, with tongue planted not-so-firmly-in-cheek, told us not to worry — we'd find out if we couldn't get off the ground before the end of the runway! Packed like sardines with our equipment taking up six of the 12 seats, Cyrano did indeed get off the ground, and over the next 36 hours we acquired a healthy respect for that old veteran of the skies.

Upon arriving at Grand Turk, observers Ted Dunham of MIT and Barbara Jones of FIT experienced a sinking feeling all too familiar to occultation observers. They found the light pollution at the airport so severe that they paid a man in a car to drop them off on a beach a few miles away, hoping to find a better site. After setting up, they acquired the field in about 30 seconds through a hole in the clouds. But the weather deteriorated and shortly after the expected time of the occultation, it began to rain. A picnic table served as a shelter for the rest of the night.

Terry Oswalt and Bruce Rafert, both of FIT, were welcomed with open arms at Providenciales. The FIT portable photometer was to make its maiden run there. Algernon Dean, an airport official, kindly designated a spot for the observing team at the end of a little-used apron off the main runway. As the music of a steel drum band wafted in from the distance, they set up their equipment and located Ceres. Several airport personnel and the police constable gathered around the team's telescope as the awaited time approached. The spectators seemed disappointed when nothing cataclysmic happened. In fact, it seemed doubtful whether an occultation had been recorded at all! A dip in intensity had occurred, but ingress was nearly a full minute late and the duration was less than half the expected 75 seconds.

Karen Meech of MIT and Edwin Strother of FIT, the observers on Great Exuma Island, really had a "tropical vacation." Having been warned that bloodthirsty mosquitoes would eat them alive after sunset if they remained at the airport, they took a taxi into George Town where they checked into the "Club Peace & Plenty," a resort hotel of some acclaim. The hotel owners, Mr. and Mrs. Stanley Benjamin, turned off the lights around the pool and dock area where Karen and Ed set up their equipment. Comfortably seated in pool chairs with blue-green luminescent fish swimming in the water less than three feet from their telescope, Karen and Ed observed a 72-second disappearance.

Jim Klavetter of MIT and Hal Provenmire and Larry Reed of FIT had driven to the Florida Keys. They selected a campground site on No Name Key away from the light pollution of tourist stops and successfully observed ingress, but spotty cloud cover interfered with their timing of egress. This site later proved to be near the center of the occultation track.

J. Allyn Smith, David Kornbluh, and Katie Izor, all of FIT, dutifully stayed behind in Melbourne on the chance that the predicted occultation track would prove wrong and pass over the FIT Observatory. A short blink, if anything, was all they expected. What they observed, however, was a 57-second disappearance!

Our planeload of observers arrived back in Melbourne in mid-afternoon the next day having traveled over 1,500 miles in less than 36 hours for an event that lasted about a minute! The Florida-based observers were waiting for us at the airport. It was there that we learned of the Melbourne observers' good fortune. This explained why the Providenciales team had seen such an unexpectedly late and brief occultation: Ceres' shadow had passed over 100 miles *north* of the last predicted track! This was an unprecedented error for such a large asteroid.

Within an uncertainty of about one percent due mostly to surface irregularities in Ceres itself, our observations fit a circular profile 590 miles in diameter. Earlier radiometric and polarimetric determinations had forecast a diameter about 10 percent larger.

This successful expedition marked the beginning of a permanent photoelectric program for asteroid occultations at FIT, which is due largely to the cooperative efforts of the students, interested amateurs, and faculty members involved.

— *Terry D. Oswalt* and
James B. Rafert
Florida Institute of Technology
Melbourne, FL

— *Edward W. Dunham*
Massachusetts Institute of Technology
Boston, MA

The price of looking it up just went *way down*!

While most unabridged dictionaries sell for unabridged prices—$50, $60, $70—this 2,300-page Webster's costs only $19.95. Through a special arrangement with the publisher, we are now able to offer this $69.95 value at a 70%—or $50—markdown from the original price! Now, you can bring this widely respected reference into your home, office, or classroom. And just look at what the Webster's contains:

- Over 320,000 Words
- More than 3,000 Illustrations
- 19 Encyclopedic Supplements
- A Thumb-Indexed Format

WEBSTER'S
NEW UNIVERSAL
UNABRIDGED
DICTIONARY
DELUXE
SECOND EDITION
SAVE $50

This Standard Reference Has Over 320,000 Words

For more than 40 years, the Webster's comprehensiveness has made it *the* standard reference. With over 320,000 words and phrases, the *Webster's New Universal Unabridged Dictionary* continues that great tradition. The Webster's defines common and obscure words, words used in other centuries and words newly created in the sciences and the humanities.

More Than 3,000 Illustrations

GIANT PANDA (6 ft. long)

The Webster's is strong on visuals, too. Finely detailed pen drawings appear throughout the text. These illustrations help make the Webster's a fun, visually exciting learning experience, especially for children.

19 Encyclopedic Supplements

Other dictionaries may contain a few supplements, but the Webster's has over *150 pages* of specialized information for every interest. Here are just *some* of the categories and features included.

- 16 pages of full-color Maps
- Dictionaries of Place Names and Geographical Features
- A Dictionary of Biography
- Dictionaries of Names from the Bible, Myths, and Fiction
- A Dictionary of Commonly Used Abbreviations
- Forms of Addresses
- The Basics of Practical Math
- Commonly Used Financial and Commercial Terms
- A Dictionary of Foreign Words and Phrases

A Tradition of Quality

Concise, correct, complete definitions have been the hallmark of the Webster's since the distinguished philologist Noah Webster published the first edition in 1806. The Webster tradition of quality also extends to its format and organization. The pages are thumb-indexed for handy reference. While other large dictionaries use eye-straining type, the Webster's features good-sized print, with defined words standing out clearly in boldface. To make reading easier still, each definition is listed on a separate line or set of lines.

We Repeat: $19.95 Is An Unbeatable Value

An *unabridged* dictionary that sells for $19.95 is a rare find, especially when the dictionary bears a famous name like Webster's. And, as with anything you buy by mail from us, our **30-day money-back guarantee** means that if you decide to return this dictionary within 30 days, we will refund your money *in full*.

SINCE 1873
Barnes & Noble
BOOKSTORES
126 Fifth Ave., Dept.W247, N.Y., N.Y. 10011

1189398. Please rush me____copies of the Webster's New Universal Unabridged Dictionary at your special sale price of $19.95 (plus $3.00 shipping & insurance per volume.) N.Y. and N.J. residents: Please add sales tax.

Name____________________________

Address____________________________

City____________________________

State______________ Zip__________

Offer good only in the continental U.S.A.

Examine this unabridged Dictionary for up to 30 days. If you are not absolutely convinced that it is the finest dictionary you ever used, you may return it for a full and prompt refund.

✓Check One
☐ Payment enclosed
☐ I prefer to charge this purchase to:

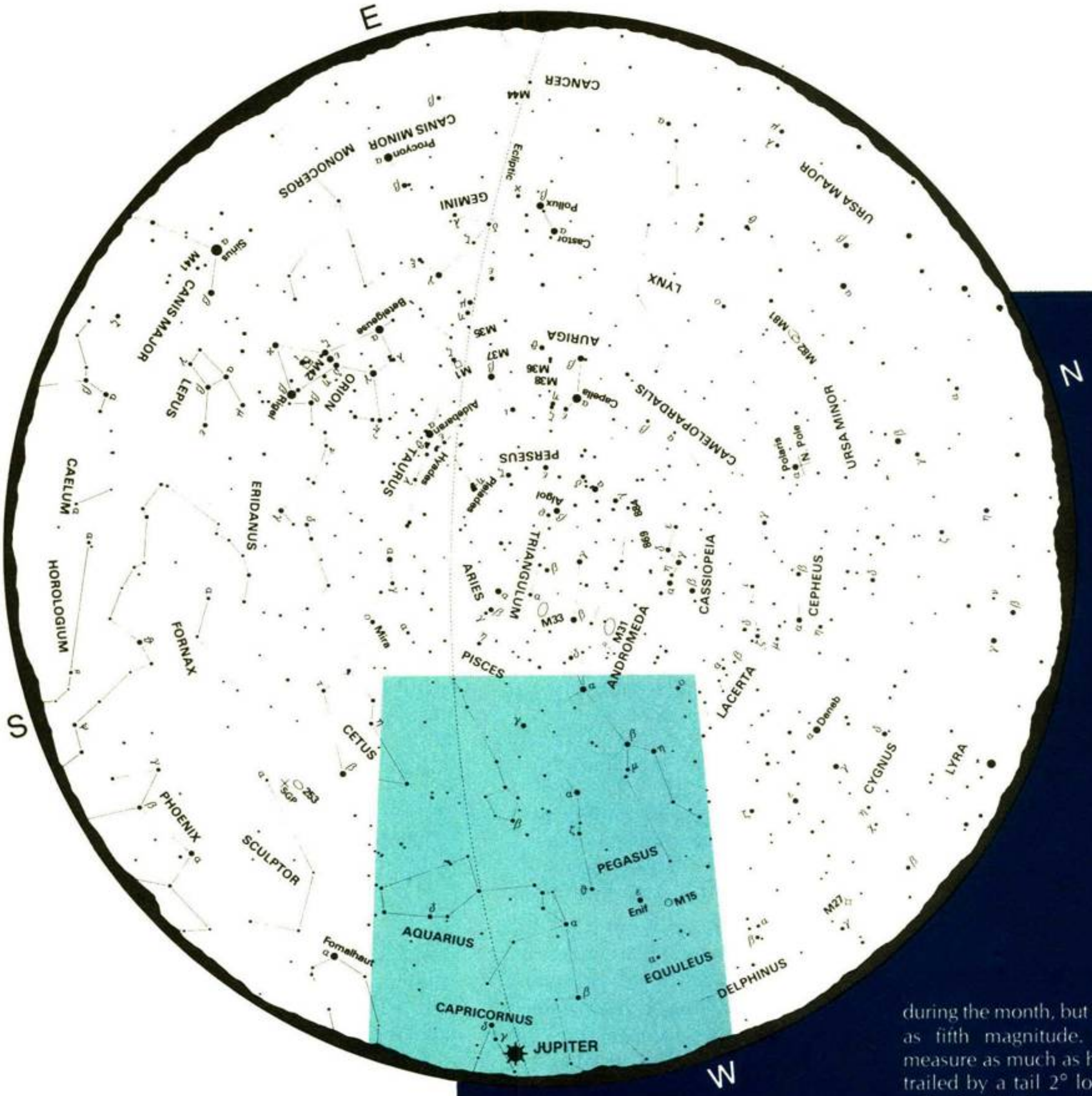
☐ American Express Card ☐ VISA ☐ Master Card

Account# ________________ Exp. ______

Signature________________________

© 1985, Barnes & Noble Bookstores, Inc.

Amateur Astronomers Observe Halley's Comet


E
N
S
W
CANCER
M44
CANIS MINOR
Procyon
MONOCEROS
GEMINI
Pollux
Castor
Ecliptic
URSA MAJOR
LYNX
Sirius
M41
CANIS MAJOR
LEPUS
Betelgeuse
ORION
Rigel
M42
M35
M37
M1
AURIGA
M36
M38
Capella
CAMELOPARDALIS
M81
M82
URSA MINOR
Polaris
N. Pole
Aldebaran
Hyades
TAURUS
Pleiades
PERSEUS
Algol
884
869
CASSIOPEIA
CEPHEUS
CAELUM
HOROLOGIUM
ERIDANUS
FORNAX
ARIES
TRIANGULUM
M33
M31
ANDROMEDA
Mira
PISCES
LACERTA
Deneb
CYGNUS
LYRA
CETUS
253
SGP
PHOENIX
SCULPTOR
PEGASUS
Enif
M15
AQUARIUS
Fomalhaut
EQUULEUS
DELPHINUS
M27
CAPRICORNUS
JUPITER

Ever since Caltech astronomers David Jewett and G. Edward Danielson first recovered the faint speck of light in December 1982, both amateur and professional astronomers have been speculating on how large and bright Halley's Comet will appear during this passage. This matter is taken very seriously by most people involved with astronomy, not only because there's normally only one chance to see the famous comet in any given person's lifetime, but also because the comet's performance may determine the public's attitude toward astronomy for a long time to come.

The Politics of Prediction

There are basically three schools of thought regarding Halley's anticipated

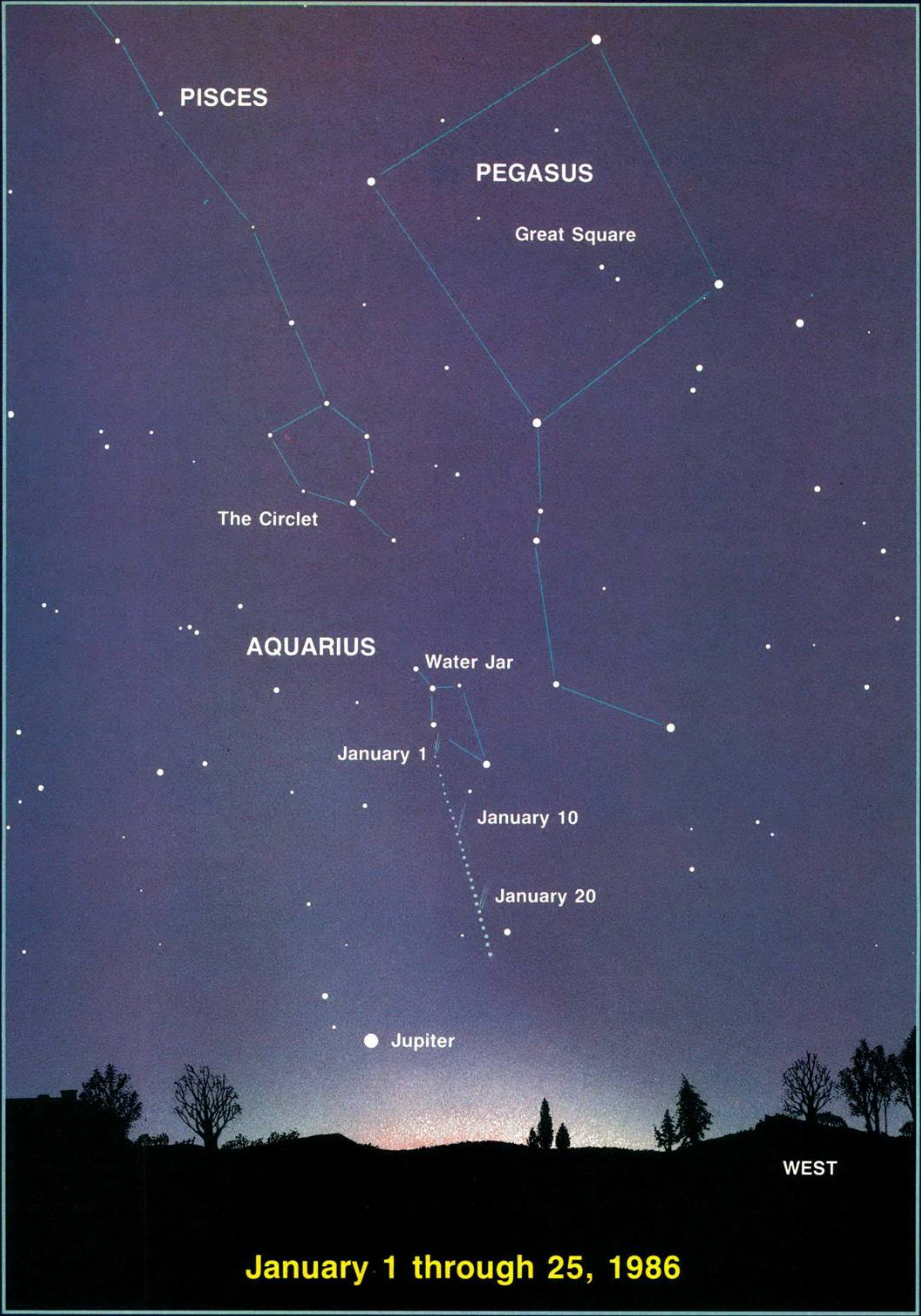
Halley's Comet in January

Despite its dim beginning, Halley should appear quite bright as the New Year starts, at least when seen in binoculars. During January, Halley is an evening object, slowly moving from the Water Jar in Aquarius down to a point south of Beta (β) Aquarii. Finding the comet should be relatively easy with either binoculars or a finderscope.

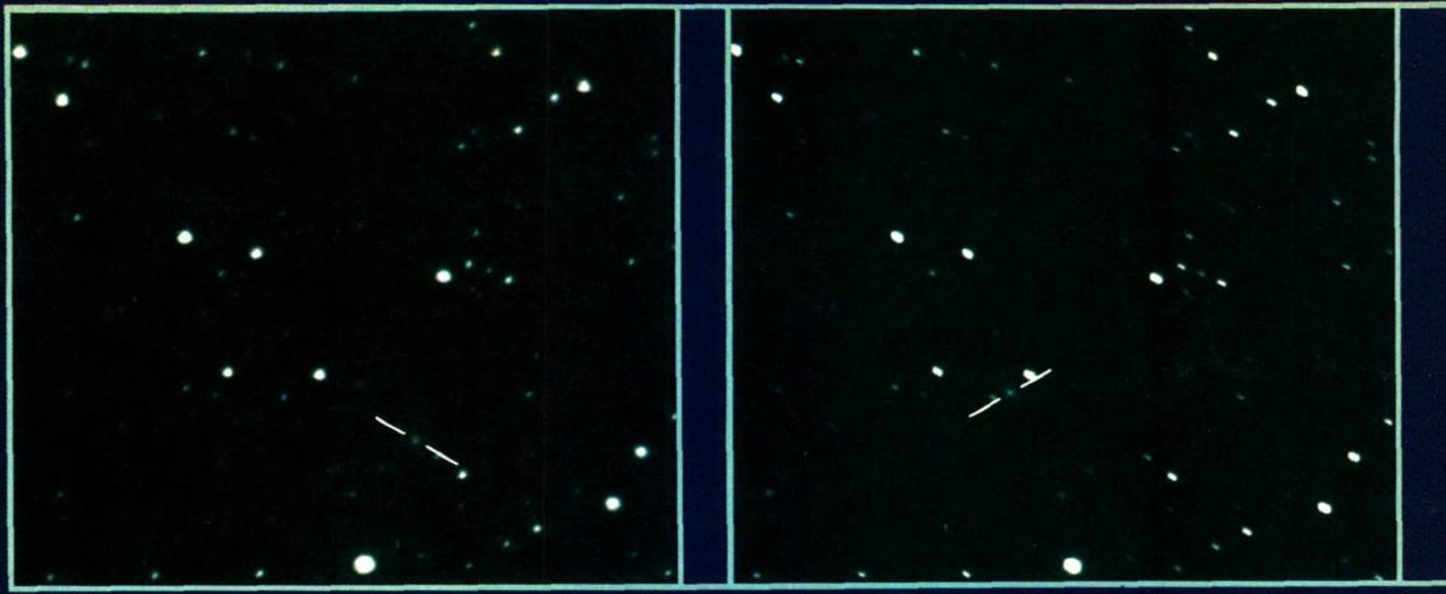
Taking into account that Halley has so far proven dimmer than everyone's predictions, it's difficult to estimate what the comet's brightness will be by January. Perhaps it's safe to say that Halley will shine at a minimum of seventh magnitude during the month, but it could be as bright as fifth magnitude. The coma could measure as much as half a degree across trailed by a tail 2° long.

To find Halley, start by locating the Great Square of Pegasus. From there, find the field of stars around Aquarius' Water Jar; then, using the accompanying chart, you'll have no trouble pinning down Halley with a finderscope or binoculars.

The best time to observe Halley in January is between the 1st, when the Moon is in the early morning sky, and the 15th, when the Moon reappears in the evening sky. After the 25th, the Sun will be too close to Halley's celestial position to let you view the comet. The cold, crisp evenings of mid-January are your last chance to see Halley's Comet before its closest approach to the Sun. The comet won't reappear until March, when it will be visible in the pre-dawn sky. See the October 1985 issue of ASTRONOMY for more detailed observing information.


PISCES
PEGASUS
Great Square
The Circlet
AQUARIUS
Water Jar
January 1
January 10
January 20
Jupiter
WEST

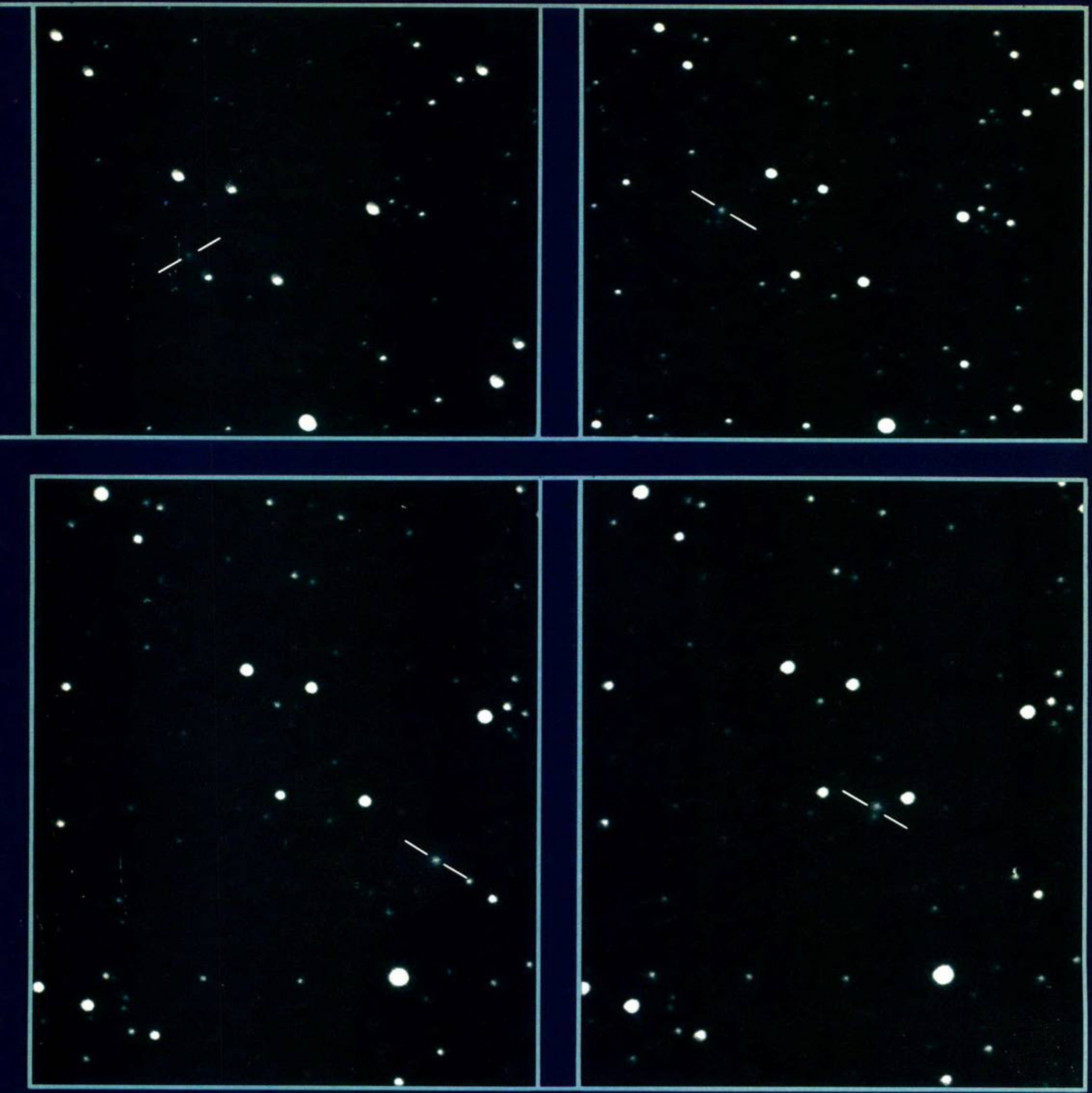
January 1 through 25, 1986



Clockwise, from upper left: The four frames along the top of the page, made on successive nights, form a series showing Halley's motion across the sky between September 13th and 16th. During mid-September, Halley (between tick marks) shone at 14th magnitude and moved about 2.2′ northeast per day. Photos by John Stull using the Alfred University 20-inch f/5.5 reflector, 103a-F film, and exposures of 30, 20, 20, and 40 minutes, respectively. The pair of photographs at bottom right show Halley as photographed on September 14th and 15th with an 8-inch f/10 SCT using 103a-O film and a 30-minute exposure. Photos by Kwan Ihn. Bottom left: On September 14th, Halley and Giacobini-Zinner (center right) lay only a few degrees apart. Photo by Paul Roques using a 4-inch f/2.6 Schmidt camera.

behavior. The first and most optimistic of these claims that Halley will become quite bright to naked-eye observers — as it did during its last apparition in 1910 — despite the fact that it is much farther from Earth this time around. The second is a "middle-of-the-road" prediction, based on many careful orbital studies and knowledge of Halley's past behavior, which states that the comet will attain a maximum brightness of magnitude 3.9 at perihelion and sprout a tail at least several degrees long. This is the prediction officially endorsed by the International Halley Watch (IHW). The third and possibly most reliable prediction is based on Halley's performance this summer after it came out from solar conjunction. According to this prediction, since Halley has been considerably fainter than anticipated — about two magnitudes, or one-sixth as bright as the IHW predictions — it will remain dimmer than anticipated. Suddenly the ghost of Comet Kohoutek — a supposedly bright comet in 1973/74 that turned out to be a dud — comes back to haunt the minds of astronomers everywhere.

Unfortunately, Halley's Comet has been a slight disappointment so far. As of October, Halley continued to run two magnitudes below the middle-of-the-road predictions at approximately magnitude 13; the IHW predicted that it would be shining at slightly brighter than magnitude 11. This lackluster performance may change, however. Comets are so unpredictable that Halley could dramatically brighten as it gets closer to the Sun, becoming an impressive naked-eye object after all. At worst — barring its unlikely disintegration — Comet Halley will be a dim object to the naked eye, but a much more impressive sight in binoculars or telescopes under dark skies.

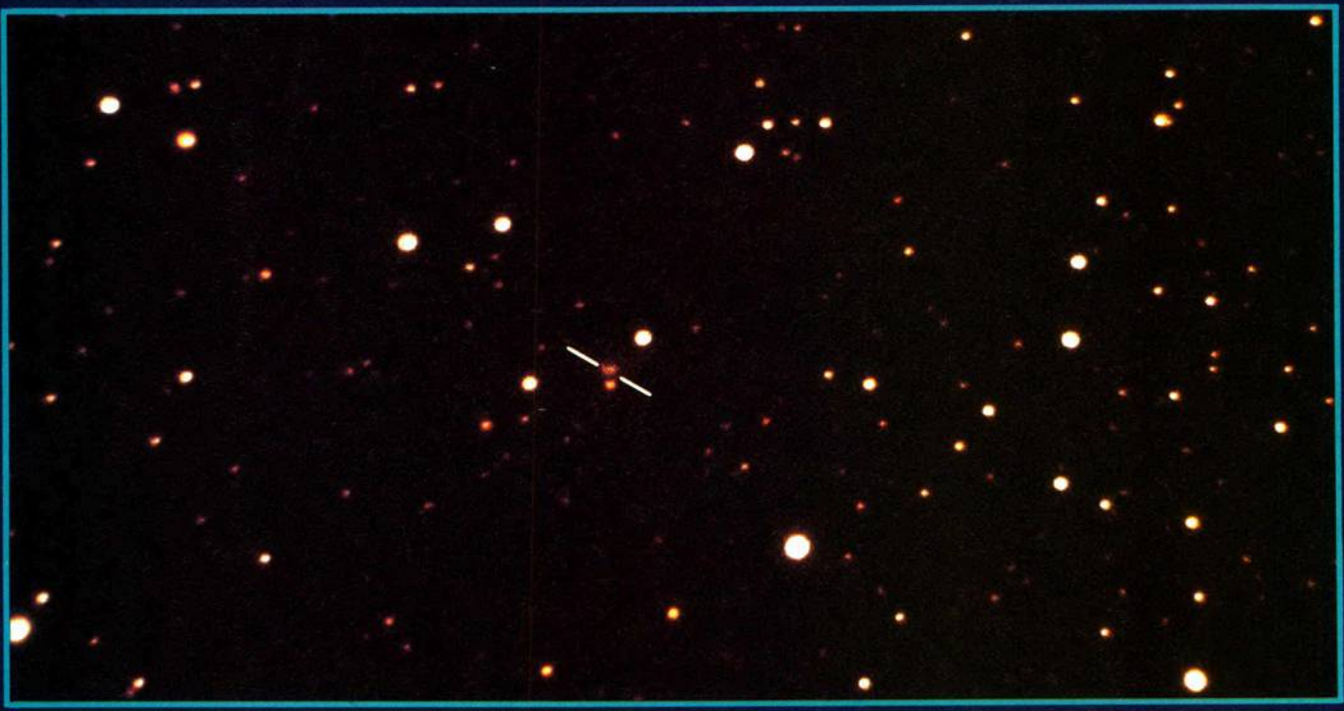


Halley from the Backyard

ASTRONOMY has received many reports from observers around the globe who have spotted Halley's Comet. In August, despite the comet's faintness, we heard from numerous people who thought they had spotted Halley using everything from 5-inch to 20-inch telescopes. In all likelihood, most of them *didn't* see Halley since it shone just a little brighter than 16th magnitude at the time.

Among the earliest amateurs to spot Halley was Jeff Corder of Tice, Florida, who wrote: "It seems that Halley has failed to brighten as expected. My first visual sighting was on August 13th with a waning crescent Moon nearby. Although the sky was excellent (magnitude 6.5 stars visible at zenith), the comet was extremely difficult [to see] in my 32 cm f/5.9 Newtonian." Jeff's letter continues, "Subsequent visual observations on the mornings of the 15th and 16th showed little more than an extremely faint object at the predicted points. My best estimate would place the comet at magnitude 15.0, 15" x 10" across, with a very faint stellar nucleus. The comet seemed extended in a north/south direction. I think ASTRONOMY will receive many such reports of this lack of brightening, especially since observers with 8-inch scopes were hoping for a first glance this month!"

By September, however, Halley had brightened considerably. By the 12th, when I saw the comet for the first time, its magnitude was 14.0. I happened to be at Lowell Observatory's Anderson Mesa station covering the comet's activity for *Deep Sky* magazine. On the afternoon of the 12th, Lowell astronomer Brian Skiff and I assisted Bill Baum, Bobby Bus, and Tobias Kriedl in setting up NASA's Space Telescope CCD (charge-coupled device)



Below: This image, made on September 15th, is one of the earliest color photographs of Halley. Photo by Kim Zussman (11-inch f/10 SCT, 3M 1000 film, 45-minute exposure). Left: On September 22nd, Canadian amateur Jack Newton recorded Halley with his 16-inch f/5 reflector using VR 100 film and a 10-minute exposure.

on Lowell's 42-inch f/16 Cassegrain. Everything seemed to be A-OK for photometry of faint asteroids that night. However, when a power supply board malfunctioned on the CCD's computer, indicating that the telescope was "down" for its intended purpose, Brian and I used the CCD previewer eyepiece to observe deep-sky objects and comets visually. By about 3 a.m. Mountain Standard Time, Taurus was high enough up in the sky to allow us to look for Comet Giacobini-Zinner (G-Z) and Comet Halley.

Giacobini-Zinner, in a 42-inch telescope, was quite bright. It had a tiny nucleus inside a coma that filled the entire field of view, and its fan-shaped tail swept clear out of the field. After gawking at G-Z for a few minutes, we slewed the massive telescope to Halley's position and, sure enough, there was a faint fuzzy patch dead center in the eyepiece. Though Halley's Comet appeared small and faint — even in a 42-inch telescope — this little fuzzy patch of light was *the* comet, the one about which so much has been said and written.

The next night in San Diego, Stephanie and John Mood had a go at finding Halley's Comet. They wrote: "The evening of Friday, September 13th, we went to a rock concert (the L.A. punk group "X") and then traveled 45 minutes out to a 6,000-foot elevation mountain near San Diego. With our 10-inch scope — which you pictured on page 48 of your September 1981 issue — we found Halley at 176x. It was very dim (one-half magnitude less than predicted?) but there it was! It's quite a thrill even two weeks later! We figured that by the 13th only 2,000 or 3,000 people had actually seen Halley."

Tucson astronomer David H. Levy, who discovered Comet 1984t from his backyard, remembered his first sighting of

Halley: "I cheated at first, because I happened to be observing on the 61-inch telescope on Mt. Lemmon [Arizona] for the International Halley Watch. In the 61-inch the comet appeared bright on September 8th, but with that much light-gathering power anything would have looked good." Levy continued, "I didn't really count the 61-inch telescope observations as sightings — I really wanted to see it using my 16-inch telescope at home, which I did on the 14th, 16th, and 20th of September. In the 16-inch the comet appeared small, circular, and fuzzy with a noticeable central brightening. Since it was moving so slowly those days and was about ready to zoom across the sky, Halley's Comet reminded me of a horse about ready to be let out of the starting gate."

From Queensland, Australia, astrophotographer Jim Barclay called about his recording Halley's Comet on September 23rd. He said: "I was up for two-and-a-half days in anticipation of photographing Halley's Comet. By the time I'd plotted its position on my copy of the *Atlas Stellarum* and had clear weather to try for the comet, I was delirious. I loaded my camera with Ilford HP5, slapped it onto the back of my 12-inch telescope, pointed it toward Halley's approximate position, and made two exposures. When I got through developing and fixing the film, I pulled it out and looked carefully. I could see a little diffused object near one corner in each frame. Boy, was I happy!"

Above: During September, Halley's Comet was still faint, so backyard observers and astrophotographers had a relatively hard time locating and photographing it. During the same time, professionals with large telescopes began serious data collecting in anticipation of the comet rapidly brightening. Here is Halley photographed on September 23rd with the U.S. Naval Observatory's 61-inch f/10 astrometric telescope (85-minute exposure on hypersensitized IIIa-J film, GG 385 filter). U.S. Naval Observatory photograph courtesy Chris Luginbuhl. Left: A double exposure shows three hours' worth of Halley's motion on October 13th. Photo by Kwan Ihn (8-inch f/10 SCT, two 20-minute exposures on 103a-E film).

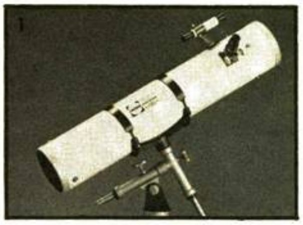
During the first two weeks of October, Halley's Comet became a 12th-magnitude object and its coma grew to several arc-minutes in diameter, making it visible in far more telescopes than in September. As this issue goes to press, we're just beginning to receive observing reports from October. Encouragingly, the comet seems to have brightened considerably between early September and early October; it now shines slightly brighter than 12th magnitude and could catch up to its original predicted brightness.

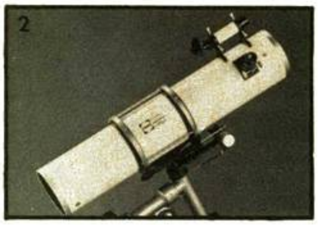
As more weeks pass and more of you see Halley's Comet, we'll look forward to receiving your comments on this once-in-a-lifetime show.

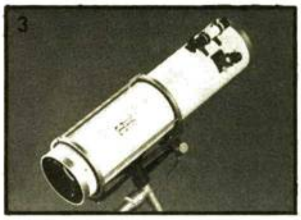
— David J. Eicher

BE A PIONEER IN THE LAST FRONTIER!

DISCOVER FIRST-HAND THE WONDERS OF THE UNIVERSE WITH *PARKS!*







PRECISION REFLECTING TELESCOPES

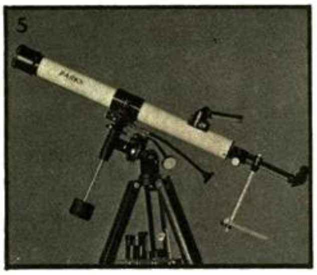
6" f/6 PRECISION NEWTONIAN TELESCOPE (1)
Includes: 6" f/6 Optical Tube Assembly with 1¼" Focuser, 6x30, Finderscope 7° field, 1" shaft Equatorial Mount, 25mm 1¼" Kellner Ocular 599.00

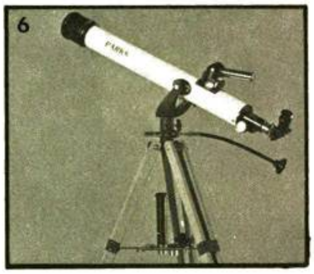
6" f/8 PRECISION NEWTONIAN TELESCOPE
Includes: 6" f/8 Optical Tube Assembly with 1¼" Focuser, 6x30 Finderscope 7° field, 1" shaft Equatorial Mount, 25mm 1¼" Kellner Ocular 599.00

8" f/6 PRECISION NEWTONIAN TELESCOPE
Includes: 8" f/6 Optical Tube Assembly with 1¼" Focuser, 6x30 Finderscope 7° field, 1" shaft Equatorial Mount, 25mm 1¼" Kellner Ocular 899.00

8" f/6 SUPERIOR NEWTONIAN TELESCOPE (2)
Includes: 8" f/6 Optical Tube Assembly with large 2" Focuser with 1¼" adaptor, giant 8x50 Finderscope, 1½" shaft mount with electric motor drive, electric push button declination slow motion control, 6" steel column, 6" engraved aluminum setting circles, 9mm and 25mm 1¼" Plossl Oculars, leveling screws, casters, fine azimuth adjuster 1899.00

10" f/5 SUPERIOR NEWTONIAN TELESCOPE (3)
Includes: Same as above model except with 10" f/6 Optical Tube Assembly 2199.00





10" f/6 SUPERIOR NEWTONIAN TELESCOPE
Includes: Same as 8" f/6 model except with 10" f/6 Optical Tube Assembly 2199.00

12½" f/5 SUPERIOR NEWTONIAN TELESCOPE
Includes: 12½" f/5 Optical Tube Assembly with large 2" Focuser with 1¼" adaptor, giant 8x50 Finderscope, 1½" shaft mounting with electric declination push button slow motion control, huge 8" steel column, 6" engraved aluminum setting circles, 9mm and 25mm 1¼" Plossl Oculars, leveling screws, fine azimuth adjuster 2899.00

12" f/6 SUPERIOR NEWTONIAN TELESCOPE
Includes: Same as above model except with 12½" f/6 Optical Tube Assembly 2899.00

12½" f/6 OBSERVATORY NEWTONIAN (4)
Includes: 12½" f/6 Optical Tube Assembly with large 2" Focuser with 1¼" adaptor, giant 8x50 Finderscope, massive 2½" shaft equatorial mounting, full giant roller bearings in both axes, oversized electric motor drive with push button electric declination slow motion controls, huge 8" steel column, engraved 12" aluminum setting circles, 9mm and 25mm 1¼" Plossl Oculars, leveling screws and casters 4699.00

PARKS REFRACTOR TELESCOPES

PRT-46 60mm EQUATORIAL REFRACTOR
Includes: 60mm x 910mm fl Refractor Tube Assembly; built in 10x Finderscope; Equatorial Mount; slow motion controls; setting circles; 4mm, 9mm and 22mm .96 oculars; 2x Barlow lens; Star diagonal; Porro Prism; solar protection screen, moon filter, adjustable wooden tripod, accessory tray with illuminator **(5)** 599.00

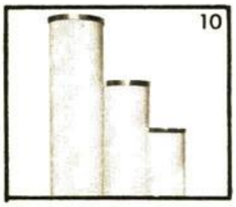
MOTOR DRIVE FOR PRT-46 .... 149.00

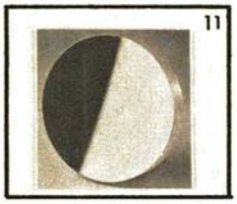
PRT-2 60mm ALTAZIMUTH REFRACTOR (6)
Includes: 60mm x 700mm Refractor Tube Assembly; built-in 10x Finderscope; Altazimuth mounting with slow motions controls; 6mm and 20mm .96 oculars 2x Barlow lens, Star diagonal, adjustable wooden tripod, and accessory tray 399.00

SPOTTING SCOPES

Comet Finder 12-50x50mm Zoom Telescope	239.00
Zoomscope 60 15-60x60mm Zoom Spotting Scope	279.00
Zoomscope 120 30-120x80mm Zoom Spotting Scope (7) ...	379.00
Super Spotter (8)	350.00
Super Spotter Camera Adaptor	22.00
Table Top Tripod (w/micro slow motion adjustments)	79.00

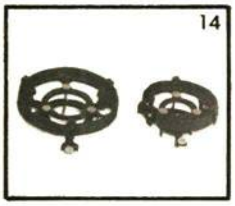
9

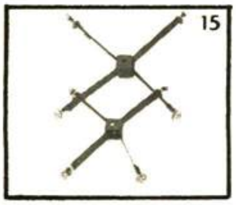

10

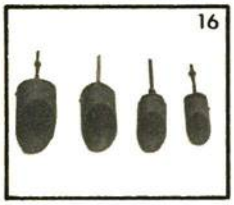

11

12

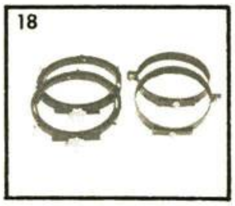
13


14


15

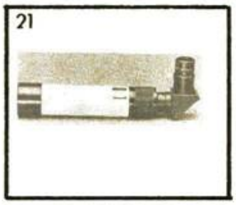

16

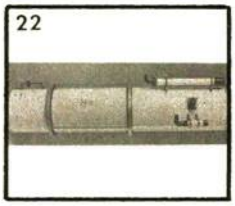
17

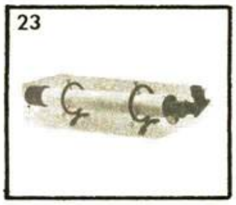

18

19

20


21


22

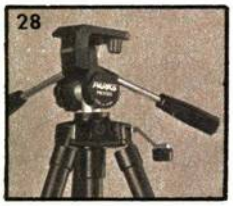

23

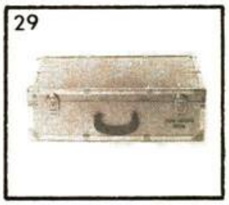
24

25

26

27


28


29

30

31

Giant Binoculars (9)

Complete with lens cap, carrying case, straps and phototripod adaptor.

11x80 Binoculars	299.00
15x80 Binoculars	299.00
20x80 Binoculars	299.00

Telescope Making Components

Fiberglass Tubes & End Rings (10)

For 4½" Mirror	
5" I.D. x 48"	39.00
For 6" Mirror	
7" I.D. x 31" to 52"	52.00
7" I.D. x 53" to 60"	56.00
Anodized Alum. End Rings per pair	20.00
For 8" Mirror	
9⅜" I.D. x 24" to 37"	56.00
9⅜" I.D. x 38" to 55"	68.00
9⅜" I.D. x 56" to 60"	72.00
9⅜" I.D. x 61" to 75"	80.00
Anodized Alum. End Rings per pair	25.00

(Cont'd)

For 10" Mirror	
11⅞" I.D. x 40" to 48"	99.00
11⅞" I.D. x 49" to 62"	116.00
11⅞" I.D. x 63" to 72"	132.00
Anodized Alum. End Rings per pair	34.00
For 12½" or 14¼" Mirror	
15⅞" I.D. x 48" to 59"	148.00
15⅞" I.D. x 60" to 69"	160.00
15⅞" I.D. x 70" to 79"	170.00
15⅞" I.D. x 80" to 100"	190.00
Anodized Alum. End Rings per pair	40.00
For 16" Mirror	
18" I.D. x 48" to 60"	160.00
18" I.D. x 61" to 90"	240.00
18" I.D. x 91" to 120"	280.00

Parabolic Primary Mirrors (11)

6" f/6 Mirror	139.00
6" f/8 Mirror	139.00
8" f/6 Mirror	219.00
8" f/7 Mirror	219.00
10" f/5 Mirror	395.00
10" f/6 Mirror	395.00
10" f/7 Mirror	395.00
12½" f/5 Mirror	699.00
12½" f/6 Mirror	699.00

PARKS OPTICAL

270 EASY ST., SIMI VALLEY, CA 93065

FOR ORDERS ONLY

(800) 43-PARKS (Calif.)
(800) 44-PARKS (Nat'l)

FOR INFORMATION ONLY
(805) 522-6722

Write or Call for Free Catalogue!
($5/U.S. For Foreign)

Elliptical Secondary Mirrors (12)

1.33" Elliptical Mirror	25.00
1.55" Elliptical Mirror	29.00
1.83" Elliptical Mirror	35.00
2.14" Elliptical Mirror	41.00
2.60" Elliptical Mirror	50.00
3.10" Elliptical Mirror	75.00

Focusers (13)

1¼" Focuser	49.00
2" Focuser (With 1¼" adaptor)	69.00

Primary Mirror Cells (14)

6" Mirror Cell	29.00
8" Mirror Cell	39.00
10" Mirror Cell	49.00
12½" Mirror Cell	69.00

Spider/Diagonal Holders (15)

Spider 7" I.D. Tube	14.00
Spider 9⅜" I.D. Tube	15.00
Spider 11⅞" I.D. Tube	16.00
Spider 15⅞" I.D. Tube	17.00
1.33" Diagonal Holder	12.00
1.55" Diagonal Holder	13.00
1.83" Diagonal Holder	14.00
2.14" Diagonal Holder	16.00
2.60" Diagonal Holder	20.00
3.10" Diagonal Holder	25.00

Setting Circles (16) (17)

6" Engraved Alum. Setting Circles 1" Bore	49.00
6" Engraved Alum. Setting Circles 1½" Bore	49.00

Mounting Rings (18)

Clamp Rings 7" I.D. Tube	50.00
Clamp Rings 9⅜" I.D. Tube	60.00
Clamp Rings 11⅞" I.D. Tube	70.00
Clamp Rings 15⅞" I.D. Tube	80.00
Rotating Rings 9⅜" I.D. Tube	195.00
Rotating Rings 11⅞" I.D. Tube	295.00
Rotating Rings 15⅞" I.D. Tube	395.00
Rotating Rings 18" I.D. Tube	495.00

Counterweights (19)

10 lb., 1" Bore	37.00
10 lb., 1½" Bore	37.00
25 lb., 1½" Bore	69.00
40 lb., 1½" Bore	99.00
40 lb., 2½" Bore	119.00
Tube Counterweight System	49.00
Extra 3 lb. Weight	19.00

Finderscopes (20) (21)

6x30", 7° field	33.00
Rt. angle, 7° field	37.00
6x30" Finderbracket	8.00
Deluxe 8x50 (Can be used straight through or rt angle, removeable 1¼" ocular 4¼° field)	139.00
8x50" Mntng. Brckts	15.00

Optical Tube Assemblies (22)

6" f/6	450.00
6" f/8	450.00
8" f/6	800.00
10" f/5	1200.00
10" f/6	1200.00
12½" f/5	1800.00
12½" f/6	1800.00

Guidescopes (23)

60mm x 700mm fl Refractor Guidescope	129.00
60mm Mounting Brackets per pair	20.00

Precision Equatorial Mountings

1" Shaft Mounting w/6" or w/8" Saddle	299.00
6" Engraved Alum. Setting Circles, 1" Bore	49.00
Electric Clock Drive	199.00
1½" Shaft Mounting w/8" or w/10" Saddle	1399.00
1½" Shaft Mounting w/12" Saddle-8" Column	1499.00
2½" Shaft Mounting w/12½" or w/16" Saddle	3299.00

ACCESSORIES

Kellner Oculars (24)

6, 12, 25, or 40mm 1¼"	30.00
50 or 60mm 2"	90.00

Orthoscopic Oculars

6, 12.5, or 25mm 1¼"	49.00

Plossl Oculars

6, 9, 12.5, 18, or 25mm 1¼"	69.00
40mm 1¼"	79.00

Erfle Oculars

20 or 32mm 1¼"	69.00
32mm 2"	149.00

Barlow Lenses

2x Barlow Lenses 1¼"	40.00
2x Barlow Lenses 2"	90.00

Visual Accessories (25)

Star Diagonal 1¼"	40.00
Hybrid Star Diagonal	40.00
Porro Prism .96"	40.00
Porro Prism 1¼"	40.00

Camera Adaptors (26)

Camera Adaptor .96"	40.00
Camera Adaptor 1¼"	40.00
Camera Adaptor 2"	40.00
Super Spotter	22.00

T-Rings (26)

Pentax 'S', Pentax 'K', Nikon, Minolta Canon, or Olympus T-Ring	12.00

Illuminated Reticle Assembly (27)

Illuminated Reticle Ocular Assembly	99.00

Photographic Tripods (28)

Photographic Tripod	150.00
Deluxe Photographic Tripod	280.00
Table Top Micro Adjustment Tripod	79.00

Other Accessories (29) (30)

Deluxe Access. Case	75.00
Collimation Tool	15.00
Observing Chair	79.00

FILTERS

Light Pollution Blocking

LPB Filter 1¼"	69.00
LPB Filter 2"	95.00

Photo Visual Color Filters **(31)** 1A, 5, 12, 15, 21, 23A, 25, 29, 38A, 47, 56, 58A, 80A, 82A, ND13, ND25, ND50	13.00 ea
Polarizing Filter	19.50 each

ASTRONOMY
In Focus

2001: No Con

Sir / I take strong exception to Thomas Bonham's "review" (August 1985) of Ray Grasshoff's review of *2010*. While approving of *2010*, Mr. Bonham describes *2001* as "an outright con perpetrated on an unsuspecting public" which "insulted the intelligence of the viewer." I find this statement astonishing. *2001* was unlike conventional science fiction precisely because it required intelligence and imagination on the part of the viewer. The movie dealt effectively with several philosophical themes such as the existence of non-human intelligences, machine intelligence, and the future development of the human race.

Mr. Bonham goes on to say that "the man and woman in the street need assistance in conceptualizing the future," and that SF films such as *Star Wars* "help provide these images." I feel a sense of sorrow when I think that the images of the future we choose to present to our children are those which emphasize glittery high-tech space warfare, rather than the profound and exhilarating possibilities so eloquently depicted in *2001*.

James B. Marshall
Annandale, VA

Science Fiction *vs.* Science Fantasy

Sir / While I don't doubt that for the U.S. space program to be successful, it must have strong public support, I do *not* think that the proper avenue for this education is Hollywood. How simple-minded does Thomas Bonham (In Focus, August 1985) think the American movie-going public is?

Let me point out some differences between science fantasy and science fiction so that movies such as *Star Wars*, *2001*, and *2010* can be properly classified. *Star Wars* and, unfortunately, a multitude of other movies like it are pure science fantasy — very shallow in content and designed simply to make money. Science fiction, on the other hand, may well spring from mercenary intentions also, but it should be factual and at best thought-provoking. *2001* and *2010* both qualify as science fiction, but the difference between them is like that between wine and grape juice.

2010 disappointed me because it was a superficial story: often predictable, riddled with technical flaws, and in the end not very thought-provoking. In contrast, *2001* keeps me wondering to this day — *that's* good science fiction. (I'll forgive the liquid dropping down the straw in zero-gravity, which is the only flaw I recall.)

I believe the best fiction (science or otherwise) is the kind people can read and interpret differently — if that isn't a test of fiction that will be remembered, then what is? *2001* is still the only film I've seen in recent years that stands up to such criteria.

Paul L. Sventek
Jakarta, Indonesia

Space Law & Contamination

Sir / While I share Mr. Loudon's concern about contamination from manned landings on Mars (In Focus, September 1985), I cannot share his faith in space law.

Article IX of the 1967 U.N. "Principles" Treaty states: "In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty . . . shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of Earth . . . and where necessary, shall adopt appropriate measures for this purpose."

The article continues that if any party to the treaty believes that their own activities or those planned by others "would cause potential harmful interference with activities of other States Parties in the peaceful exploration and use of outer space," then they should begin "appropriate international consultations."

Yet what is "harmful contamination"? Harmful to whom? The enforcement provision seems to mean "harmful to the continued exploration and use by other parties," not "harmful to native life." However, it could be argued that contaminating Mars by Earth organisms would certainly harm the use of Mars as a laboratory for studying the development of life, but is this really what the treaty is trying to prevent? To me, it reads more like a prohibition on making celestial bodies "harmful to human life."

But regardless of what "harmful contamination" actually means, the treaty still couldn't do what Mr. Loudon wishes for a very simple reason: the enforcement clause requires only "consultations." And should a party refuse to consult, the treaty primarily calls on "negotiations" to settle the dispute.

The "Principles" Treaty is going to work only if nations on Earth recognize the value of preserving Mars and, through self-restraint, avoid contaminating the place. But whatever happens will occur in spite of the treaty's provisions, not because of them.

Darlene Cypser
Norman, OK

— Jim Loudon replies: Perhaps "treaty" is a technical term in law that I misused. I had in mind not the vague United Nations "Principles" Treaty of 1967, which Ms. Cypser quotes, but the much more specific COSPAR agreement of the same year regarding planetary quarantine.

I don't know enough history to say if the COSPAR agreement was specifically intended to enforce the "Principles" Treaty, but I do know that both the U.S. and the Soviet Union ratified it, that it extends for 50 Earth years, and that it's why the Viking landers were sterilized despite great difficulty and expense.

I cited it briefly only because Linda Joan Strand, whose concerns for Jupiter parallel mine for Mars, had discussed it in detail (see "The Star Tar in the Jupiter Jars," ASTRONOMY, *June 1984) and I was trying hard to obey the rule that a letter to the editor should be brief.*

Perseid Fireball at Dusk

Sir / On August 12, 1985 — the evening of the Perseid shower — I saw an unusual meteor. It was around 8:30 p.m. and the Sun was approximately 2° above the horizon. I happened to look up and at that moment a brilliant bolide streaked across the sky from north to south. It was visible for about five seconds and left a tail which I estimated to be 30° long.

Later I traced the bolide's flight line back through Polaris down to the northern horizon, where Perseus was at the time. I've heard of bolides occurring in the daytime, but never thought I'd see one!

Sharon V. O'Neill
Pittsburgh, PA

You-RAH-Nuss

Sir / I'm sure I speak for many other right-thinking Americans when I say that the name of the planet Uranus — no matter which way you pronounce it — is more than a little disgusting.

I'm an elementary school teacher; and it makes me queasy every time I have to discuss the planets with my sixth-graders. You smart-guy astronomers think you have to name all the heavenly bodies after characters from Greek and Roman mythology.

Fiddle-faddle, I say. Let's give the planets good, clean, wholesome names like Chuck or Marjorie and keep our solar system smut-free!

Mildred Butz
Skiatook, OK

— *Try "you-RAH-nuss."*

Does Anyone Know . . .?

Sir / I am trying to determine the date and place of manufacture of a brass refracting telescope that appears at least 50 years old.

The main tube of the telescope is 7.5 centimeters in diameter and 96 cm long. The breech, where the focusing tube fits, is inscribed with "Bardou & Son Paris" and a small symbol measuring 1 cm by 1 cm consisting of a caduceus flanked by the letters "GB" and the words "Trade Mark" underneath.

The telescope is also equipped with a small finder, a focusing knob, and an alt-azimuth mount with three folding legs that measures about 42 cm high.

If readers can help provide any information, I'd appreciate hearing from them.

Prof. Peter Shull
Department of Physics
Oklahoma State University
Stillwater, OK 74078

Speaking of Fireflies

Sir / One night I went out back to take a look at the stars during a meteor shower. I opened a beer, leaned back in my lawn chair and started staring up, hoping to see a shooting star.

A lightning bug blinked about a foot in front of my face and zipped past my nose. It almost caused me an instant cardiac arrest. There was one microsecond of sheer terror before I realized I had been buzzed by a bug and not had a close encounter with a meteor. The universe ain't dull!

Sammy L. Franks
Austin, TX

— *How many beers was that?*

Ooops!

The photograph of Halley's Comet on page 112 (top left) of the October 1985 issue was taken by Bruce Goldberg of NASA's Jet Propulsion Laboratory, Ian Halliday, Allan Cook, and Bruce MacIntosh of the Herzberg Institute of Astrophysics, and Chris Aikman of the Dominion Astrophysical Observatory. They used the Canada-France-Hawaii Telescope in Hawaii.

Behind the Scenes

Bytes and Building

In our January issues we often explore one of the great observatories of the world. This year we decided to look to the future, to the Hubble Space Telescope. We have concentrated on a crucial aspect of this first great space observatory — the making of its ultra-precise optical system. Scheduled for launch late this year, the HST will almost certainly revolutionize optical astronomy by the end of this decade.

We're looking to the future in a different way in this month's feature article, "Deep Time." While that too-distant future doesn't affect my daily life or yours, the possibilities are utterly mind-boggling. I don't think we humans can comprehend, except intellectually, what a million years means, let alone the passing of a billion. A billion trillion is just so much noise, and a googol of years (10^{100}) is utterly ridiculous. Still, we keep trying.

This month, Dave Eicher and I spent several days snapping copy photos and running to the "Foto Fast" store in Milwaukee's Grand Avenue Mall to shoot the illustrations for this month's Photography in Astronomy. I'm impressed with the results we got. The simple image enhancement techniques described in the article work quite well and are suitable for many of today's "no space for a darkroom" astrophotographers. The next time your astrophotos turn out dull, give these techniques a try.

On another front, our STARS.BAS program ("How to Plot Star Maps on Your Computer," August 1985) has been incredibly popular. We have distributed nearly a thousand copies. There are, however, two little bugs you should fix: renumber line 330 as line 305, then delete line 330; and add the expression :PSET (X,Y+1) to the end of line 440. The first change makes the program more efficient, the second puts the "missing pixel" back in the star image.

Finally, a note about my book, *Build Your Own Telescope*. People have asked, "Did you actually build *all five* telescopes?" as if it were something terribly difficult. The answer is yes, and I enjoyed making every one of them. But that's not why I wrote the book. In the last analysis, *Build Your Own Telescope* exists for those of you who have telephoned me over the years with questions and told me how much you wanted a book with plans for building telescopes. It took me a while, but I wrote it for you.

Sincerely,

Richard Berry

Richard Berry
Editor-in-Chief

You can see
to make the wo

The Celestron precision optics you see below took more than twenty years to get here. That's how long we've been designing, building and perfecting our optics. And why, inside where it counts, our instruments don't look like everyone else's.

Before our optics reach out for distant worlds, they must first reach other destinations no less important. One is called quality, the other reliability.

To get there we computer-design, hand-collimate and laser test. We "figure" our optics to better than the "diffraction limit," 1/10 wave (about a millionth of an inch). And all the while we maintain a level of craftsmanship that has set standards for the industry. The results are easy to see.

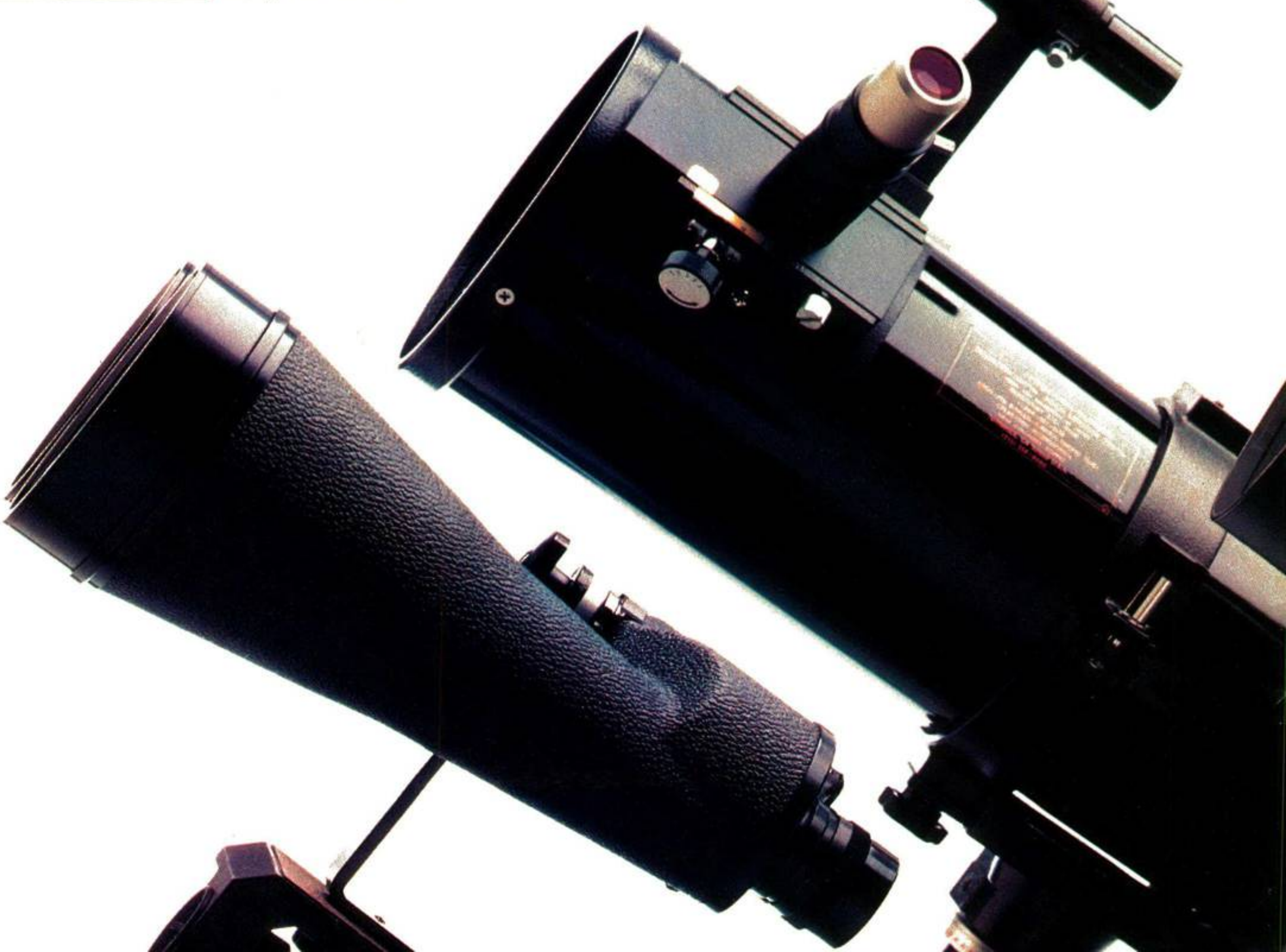
Our 11X80 Giant Binoculars are a great way to introduce someone to astronomy and an excellent companion to any telescope.

They're comfortable. Ideal for wide-angle scanning. With the ability to put the night sky into a perspective that's completely different from any telescope. They're also perfect for tracking comets.

A 7.1mm exit pupil provides the brightest possible image. Lenses are coated with magnesium fluoride for high light transmission. A tripod adapter and carrying case come standard.

For the serious beginner, our C6 Newtonian Reflector is the classic first telescope. It's a superb wide-angle low-power instrument and the smallest reflector we advise for deep sky observing.

Low-expansion optical glass delivers stable images. Mirrors are multicoated for high light transmission. And the slide focus system works for astrophotography without



how far we go orld's finest optics.

changing the position of any mirrors.

Standard features include a built-in worm gear, slow motion controls, setting circles and a multicoated Plossl ocular.

An optional Super Polaris version makes the C6 computer-adaptable. While an optional drive system with built-in corrector works in either hemisphere. Best of all, the C6 is less than half the cost of our Super C8 Plus.

Yet when you're ready, the Super C8 Plus will take you as far as you want to go.

It's the perfect balance between portability and large-diameter light-gathering ability. An 8-inch diameter, 2000mm focal length and f/10 focal ratio give the Super C8 Plus visual and photographic capabilities that are simply amazing.

A Swing-through Fork Mount and Byers Worm Gear drive come standard. So do setting circles, slow motion controls for both axes, an 8X50 polar alignment finderscope and two oculars: a multicoated Plossl and a fully-coated Orthoscopic.

For both visual and photographic applications, the most extensive list of accessories in the industry is available.

Completing each package is a free one year subscription to *Deep Sky* magazine and our limited lifetime warranty.

The 11X80 Giants. C6 Newtonian. Super C8 Plus. You can see how far we go to make the world's finest optics. Luckily, you don't have to go the same distance to own them.

Only as far as your nearest Celestron dealer.

Simulated views through 11x80 Giant Binoculars, C6 and Super C8 Plus.

CELESTRON®

Celestron International
P.O. Box 3578, 2835 Columbia St.,
Torrance, CA 90503 (213) 328-9560

For more information and the name of the dealer nearest you, call Free 1-800-421-1526 (Mon.-Fri., 8–4:00 pm; Continental USA only). For a catalog, send $3.00 to Celestron International.

ASTRONOMY Reviews

6-inch f/8 Apochromatic Refractor
Model 706 German equatorial mount
optical tube assembly, $1295
equatorial mount, $1995
Astro-Physics Corp.
Rockford, IL

Every decade or so, there is an innovation in telescope technology that alters the whole field. The Schmidt-Cassegrain telescope, two decades ago, was one such invention; the Dobsonian mounting was another. The latest such development is the perfection of the apochromatic refractor by Roland Christen, head of a small company named Astro-Physics. Although refractors have long been held in high regard, Christen's new line of color-free apochromatic systems provide unparalleled performance at a price competitive with conventional achromatic refractors.

Conventional two-element lenses, and many three-, four-, and five-element lens systems, fail to satisfactorily reduce chromatic aberration in refractors. The remaining color aberration, or "secondary spectrum," places severe limits on the shortest focal ratio capable of producing well-corrected images for a given aperture. For a conventional doublet with a 3-inch aperture, the focal ratio must be f/8 or greater; for a 4-inch, f/10; and for a 6-inch, f/15. Although they perform reasonably well despite their shorter focal ratios, achromatic refractors suffer from color error.

Enter the *apo*chromatic refractor. By designing a refractor lens using three glasses (one having "abnormal" optical properties), it is possible to significantly improve on the two-element lens. This does not mean "the more elements the better" — the glass used must be the right type. Roland Christen, who has spent some 10 years designing apochromatic refractors, has now brought these exceptionally fine and versatile lenses within the reach of amateurs on an average budget.

I had a 6-inch f/8 Astro-Physics apochromatic refractor and model 706 German equatorial head and pier on loan for three weeks. During that time, I managed to put it through its paces quite thoroughly. For an instrument of this aperture and such short focal length, the performance was little short of stunning.

The telescope arrived in a large box, complete with dew cap, mounting rings, a massive focuser unit, and 1.25- and 2-inch eyepiece adaptors. Construction quality was excellent — the solidly-made 2.5-inch focuser being the latest refinement in a steadily evolving design. Finished in white, the instrument had a spare, almost utilitarian, look about it but its performance was extravagant. At less than 20 pounds and a bit over 4 feet long, it was hard to believe this compact unit was a 6-inch refractor. Doublets of this aperture typically require eight-foot tubes.

The Model 706 mounting and pier were equally solid. The turnbuckle and rod-braced pier is, for all its simplicity, exceedingly rigid, supporting the equatorial head better than just about any other design I've seen. The pier weighs 40 pounds and the mount weighs another 50 pounds, including counterweights.

The equatorial head is machined from heavy aluminum castings. It worked very well: the slow motions were smooth and backlash-free, and the drive tracked well even at high magnification. It did not disappoint us once during testing. However, I would like to see a better way of setting the equatorial's latitude. In the unit evaluated, adjusting the polar angle required using a box-end wrench and "fussing" until the polar angle was set within a fraction of a degree. Once set, though, it stayed in adjustment. The total setup time, including polar alignment, was about 15 minutes.

As noted above, the optical performance of the Christen 6-inch f/8 apochromatic objective is little short of stunning. The objective is available in two different "color corrections" — visual and photographic — and in two different focal ratios — f/8 and f/12. Each color correction is optimized for its purpose; the visual correction is fine-tuned to give the best images in the yellow-green light our eyes are most sensitive to, while the photographic version is best in blue light. As with achromats, apochromats perform their best at longer focal ratios. The f/8 version is intended for all-around use, while the f/12 version is made for those who demand the very best color correction available. Although the lens evaluated was the photographic version of the f/8 lens and theoretically the "worst" of the four possibilities, it still delivered outstanding performance.

I carefully compared the Christen 6-inch f/8 apochromat to a high-quality 6-inch f/15 achromatic refractor, an 8-inch SCT, and a 10-inch Newtonian with an excellent mirror. Of the four instruments, only the 10-inch Newtonian, which had 60% greater aperture and nearly triple the collecting area, compared favorably in resolving power and overall image brilliance. There was no contest with the 8-inch SCT — *both* of the refractors beat it hands down.

The most telling comparison came between the two refractors. Six-inch f/15 achromatic refractors have long been a standard of quality that few amateur instruments can match. A 6-inch f/15 doublet is, however, handicapped by significant secondary spectrum. Around a bright star image, the observer sees a halo of purplish light nearly one minute of arc across. The saving grace of doublet refractors is that they form a crisp, contrasty star image in yellow-green light.

The 6-inch f/8 Christen photo-apochromat, while not perfect, displayed considerably less secondary spectrum than the f/15 doublet. This version of the lens, which has minimum focus in the blue, still combines the violet, green, yellow, and orange quite well. Red light, however, focuses farther from the lens, forming a slight crimson halo around bright objects. Epsilon Lyrae, for example, was cleanly split, but each star was surrounded by a faint ruddy halo of light.

Saturn — crisp, clearly defined, and showing Cassini's Division in sharp contrast — was also subtly red-rimmed. It bears re-emphasis, however, that the f/8 photo-triplet's images were considerably better than those of a high-quality 6-inch f/15 visually-corrected refractor.

A month after I returned the apochromat to Astro-Physics, I saw one of the 6-inch f/8 visually-corrected triplets at Stellafane. The visual version of the lens is virtually color-free with no trace of the red halo characteristic of the photographic version. Unless astrophotography were a determining factor, I would certainly prefer the visual version of the f/8 instrument; better yet, I would get the f/12 version, in which chromatic aberration would be almost non-existent.

One interesting side effect of the Christen triplet's superb image quality is that the faintest stars visible are roughly half a magnitude fainter than for doublet refractors or reflectors of the same aperture. The reason for this, presumably, is that all the light entering the triplet telescope ends up concentrated in the image, whereas in the doublet, considerable light is spread into the purplish halo surrounding a yellowish image core. Reflectors suffer from lower "throughput" due to the 88% reflectivity of aluminized and overcoated mirrors, the obstruction of the secondary, and the larger diffraction pattern caused by the obstruction. The same probably holds true of SCTs, but I did not have a 6-inch SCT on hand for direct comparison.

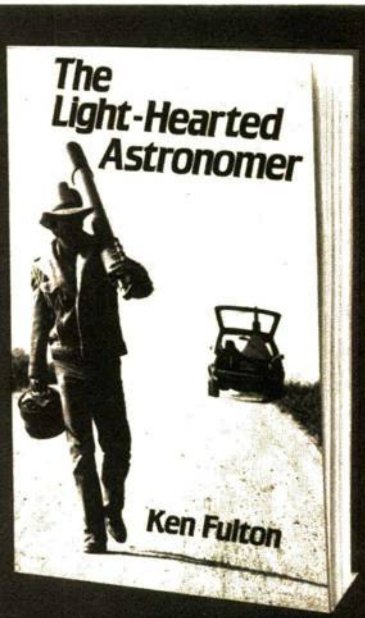
The Astro-Physics 6-inch f/8 refractor with its Christen triplet lens sets a new standard for optical quality in telescopes on the amateur market at a quality/price ratio that's hard to beat. With relatively minor cosmetic improvements and redesign of the latitude adjustment for the equatorial head — neither of which posed any real problem and which are now in the works, according to Christen — the model 706 equatorial mount will be tops in all categories. I recommend the visually-corrected lens unless astrophotography is an all-consuming passion, or the f/12 lens if you want the ultimate in planetary images. I found the f/8 focal ratio an excellent all-around compromise, suitable for low-power observing as well as high-power splitting of double stars and observing planetary detail. If I didn't already have a house full of telescopes, I would have placed my order for one. *Richard Berry.*

The Hidden Universe
Michael Disney
257 pages, hardcover, $17.95
Macmillan (1984)

In this intriguing and informative book, Michael Disney describes the current state of affairs in astronomers' attempts to understand the composition and evolution of the universe. Although dramatic progress has been made in this field over the last few years, scientists are faced with the fact that most of the material of the cosmos is apparently invisible, and its nature and properties are unknown. The mystery of this "missing mass" is a contemporary example of one of the ironies of scientific discovery: the more knowledge we amass, the more apparent is our ignorance!

Disney points out that what is popularly referred to as missing mass is really missing *light*. The gravitational influence of this mass on galaxies and clusters is measurable, but the matter cannot be seen. A related but separate problem is whether this matter is sufficient to raise the density of the universe above a critical value. If the density is high enough, the observed expansion of the cosmos wil halt and the universe will eventually collapse on itself.

To give the reader a clear understanding of the issue and its implications, Disney begins with an extensive overview of fundamental concepts in astronomy, including the characteristics and evolution of stars, the structure of galaxies, theories of gravitation, and the universal expansion. This information, presented in a very readable style with a personal flavor, provides a solid foundation for the



"I made a big mistake when I purchased my first telescope. How I wish Fulton would have written this book sooner!"
— *Galileo*

"Fulton has done astronomy an invaluable service. I think a lunar crater should be named after him."
— *Plato*

SECOND BIG PRINTING!

The Light-Hearted Astronomer

A Survival Manual for Amateur Astronomers

Written by Ken Fulton, a frequent contributor to ASTRONOMY, **The Light-Hearted Astronomer** includes chapters such as: Amateur Astronomers — A Strange Breed; The Ads; The Telescopes; What Accessories Do You Really Need?; Seeing What You Observe, Observing What You See; Living With a Non-Astronomer Spouse; Is the Universe a Harsh Mistress? In his distinctive and humorous style, Fulton tackles these topics and many more. This new book offers something never yet published: a "survival manual" for amateur astronomers that tells it like it *really* is!

128 pages, paperback, 5½" x 8½"

The Light-Hearted Astronomer $6.95

To order, use the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

extensive enumeration of current theories which follows.

As each idea is ruled out as an answer to the problem, the reader begins to appreciate the fascination, excitement, and frustration of scientific work. Although no definite conclusion can be outlined, Disney rescues the discussion from anticlimax with an intriguing chapter relating some of his thoughts on the subject. The book concludes with a concise summary of future research efforts which may resolve some of the major questions.

Although it is a very well-written work in general, one negative point bears mention. This concerns the definition and use of the cosmic density parameter, omega. A very important quantity which figures prominently in the book, omega, as Disney defines it, is the ratio of the actual density of space to a critical value calculable from the expansion rate. Apparently, according to the definition, the parameter cannot be negative; however, Disney uses values less than zero in his discussions without elaboration. When I checked with other references, I found that omega can indeed take on negative values for universes in which spontaneous creation of matter is allowed. But this point was never addressed in the book and the discrepancy causes no small amount of confusion.

All the same, Michael Disney has done an outstanding job of presenting a complicated topic in a clear and readable fashion. The reader is provided with summaries at critical junctures, and can refer to a comprehensive index and annotated bibliography. In sum, *The Hidden Universe* is a nearly complete, informative work and is highly recommended. *David Jourdan.*

Theory and Experiment in Gravitational Physics
Clifford M. Will
342 pages, paperback, $24.95
Cambridge University Press (1985)

This work was first published in hardcover in 1981; it deals with research on general relativity performed over the past two decades and recent tests made of the theory. The book summarizes both the classical tests (advance of Mercury's perihelion, light deflection, and so on) as well as the newer areas for testing found in cosmology and high-energy astrophysics. The work is aimed at the professional scientist.

The Moon and the Planets
William R. Corliss, compiler
377 pages, hardcover, $18.95
The Sourcebook Project (1985)
[Publisher's address: P.O. Box 107,
Glen Arm, MD 21057]

Corliss has combed, "without grants, contracts, or donations," the scientific and popular literature published in the U.S. and Great Britain for anything to do with the Moon and planets that seemed inexplicable — anomalies, in short. These range from supposed natural satellites of Earth (other than the Moon) to the mechanism powering Io's volcanoes to transient lunar phenomena. All entries carry full bibliographic citations for anyone interested in finding the original reports.

Cepheids: Theory and Observations
Barry F. Madore, ed.
300 pages, hardcover, $39.50
Cambridge University Press (1985)

Cepheids are probably the most famous variable stars, since they gave astronomers a key to understanding the scale of the universe half a century ago. This volume reprints the papers from an IAU symposium in Toronto during May and June, 1984, on the 200th anniversary of the discovery of Cepheid variability. The papers focus on the physical structure of Cepheids, their evolution, and how they affect galactic studies.

Architecture de l'Universe
Serge Brunier
184 pages, hardcover, 245F (about $29)
Bordas (1985).
[Publisher's address: 17, rue Remy-Dumoncel, 75661 Paris, France]

This large-format, heavily illustrated picture book of astronomy is by a French amateur/professional astronomer. Ten chapters address such matters as the place of mankind in the universe, the Sun and its planets, the types of stars, and galaxies and cosmology. The last two chapters examine the likelihood of intelligent life elsewhere and the future of astronomy.

Perfect Symmetry
Heinz R. Pagels
390 pages, hardcover, $18.95
Simon and Schuster (1985)

Subtitled "The Search for the Beginning of Time," this work attempts to explain what cosmologists have learned about the universe right at the Big Bang — before the first billionth of a second had passed. This entails explaining a lot of astronomy, cosmology, and physics; Pagel is writing for the interested layman.

Reports on Astronomy
Richard M. West, ed.
726 pages, hardcover, $69
D. Reidel (1985)

The scientific work of the International Astronomical Union is carried out in its many commissions, each of which is devoted to a single area of research, such as positional astronomy or variable stars. This volume contains reports of each commission's work done between July 1981 and June 1984.

Cool Stars with Excesses of Heavy Elements
Mercedes Jaschek and Philip C. Keenan, eds.
398 pages, hardcover, $54
D. Reidel (1985)

This book reprints 51 papers given at a professional conference held in Strasbourg, France in July 1984. Topics include spectral characteristics of peculiar cool stars, photometric properties, membership in clusters, chemical composition, and model atmospheres.

The Cambridge Atlas of Astronomy
Jean Audouze and Guy Israel, eds.
432 pages, hardcover, $75
Cambridge University Press (1985)

The Atlas is a large-format, heavily illustrated "encyclopedia" of astronomy. It is intended for the interested layman and is arranged in essay form. The first section, for example, is on the Sun and includes articles on the photosphere, internal structure, corona, solar wind, and the solar sunspot cycle. The other sections deal with the solar system, stars and the Galaxy, and other galaxies and cosmology. Several essays at the end discuss new astronomical instruments and the history of the science. There is also a sky map, glossary, and index.

James E. Keeler: Pioneer American Astrophysicist
Donald E. Osterbrock
411 pages, hardcover, $39.50
Cambridge University Press (1984)

James Keeler is little heard-of today, but at the time of his sudden early death (at age 42, in 1900) he was one of the best-known and respected American astronomers. This biography, by the present director of Lick Observatory, traces Keeler's scientific career from his boyhood in Illinois to the directorship of Lick, the post he occupied when he died.

Cataclysmic Variables and Low-Mass X-ray Binaries
Donald Q. Lamb and
Joseph Patterson, eds.
452 pages, hardcover, $59.50
D. Reidel (1985)

Cataclysmic variables are stars that suddenly and unpredictably erupt, skyrocketing several magnitudes for a brief time and then dropping back to their former brightness. They are thought to be small binary star systems, which are actively transferring mass from a large star to a smaller one. Low-mass X-ray binaries have many similarities, though the star on the receiving end is probably a neutron star. This book records the papers given at a conference held in Cambridge, Massachusetts in January 1983.

Statement of Ownership, Management and Circulation

(Required by 39 U.S.C. 3685)

1A. Title of publication: ASTRONOMY.

1B. Publication No.: 916358.

2. Date of filing: September 30, 1985.

3. Frequency of issue: monthly. 3A. Number of issues published annually: 12. 3B. Annual subscription price: $21.00.

4. Complete mailing address of known office of publication: 625 E. St. Paul Ave., Milwaukee, WI 53202.

5. Complete mailing address of the headquarters or general business offices of publisher: 1027 N. 7th St., Milwaukee, WI 53233.

6. Full names and mailing addresses of publisher, editor, and managing editor: Publisher, Robert A. Maas, 625 E. St. Paul Ave., Milwaukee, WI 53202; Editor, Richard Berry, 625 E. St. Paul Ave., Milwaukee, WI 53202; Managing Editor, Stephen Cole, 625 E. St. Paul Ave., Milwaukee, WI 53202.

7. Owner: Kalmbach Publishing Co., 1027 N. 7th St., Milwaukee, WI 53233; stockholders owning or holding 1 percent or more of total amount of stock are: Dorothy W. Akin, 698 Cardiff Dr., Hartland, WI 53029; William A. Akin, Jr., 2544 N. 124 St., #311, Wauwatosa, WI 53226; William B. Calhoun, Jr., Box 2166, Estes Park, CO 80517; Drayton Cochran, c/o Wellington & Co., 120 Broadway, New York, NY 10005; Alexander L.H. Darragh, Route 8, Box 95, Harrison, AR 72601; George A. Gloff, 1027 N. 7th St., Milwaukee, WI 53233; Elizabeth K. Grunden, 10926 Leaning Ash Lane, Houston, TX 77079; Linda H. Hanson, 614 S. Grove, Barrington, IL 60010; Robert L. Hayden, Jr., 1027 N. 7th St., Milwaukee, WI 53233; Dr. H.W. Hein, 2549 S. Kinnickinnic Ave., Milwaukee, WI 53207; George F. Hirschmann Trust, 635 Glenridge Dr., Glenview, IL 60025; Margaret Jenkins, 2434 N. 102 St., Wauwatosa, WI 53226; Charles A. Kalmbach, 7435 N. Braeburn Lane, Glendale, WI 53209; William H. Kalmbach, 206 W. Johanna, Austin, TX 78704; James J. King, 1027 N. 7th St., Milwaukee, WI 53233; Kathryn Mahnke, 10006 La Placita Dr., Rancho Cordova, CA 95670; Ray J. Mertz, 2462 N. Prospect Ave., Milwaukee, WI 53211; David P. Morgan, 1027 N. 7th St., Milwaukee, WI 53233; Walter J. Mundschau, 1027 N. 7th St., Milwaukee, WI 53233; Norma Thornburgh, 5530 80th St., N., St. Petersburg, FL 33709.

8. Known bondholders, mortgagees, and other security holders owning or holding 1% or more of total amount of bonds, mortgages, or other securities: First Bank (N.A.), 201 W. Wisconsin Ave., Milwaukee, WI 53259; AstroMedia Corp., 625 E. St. Paul Ave., Milwaukee, WI 53202.

9. For completion by nonprofit organization authorized to mail at special rates (Section 423.12 DMM only): not applicable.

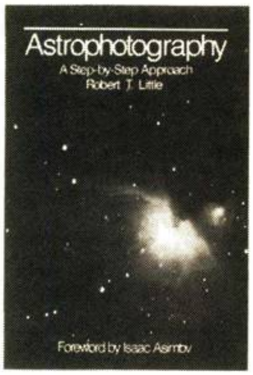
10. Extent and nature of circulation: 10A. Total number of copies printed (net press run): average number of copies each issue during preceding 12 months: 194,500; actual number of copies of single issue published nearest to filing date: 260,000. 10B. Paid and/or requested circulation: 10B1. Sales through dealers and carriers, street vendors, and counter sales: average number of copies each issue published nearest to filing date: 83,328; actual number of copies of single issue published nearest to filing date: 116,311. 10B2. Mail subscription (paid and/or requested): average number of copies each issue during preceding 12 months: 101,294; actual number of copies of single issue published nearest to filing date: 109,790. 10C. Total paid and/or requested circulation (sum of B1 and B2): average number of copies each issue during preceding 12 months: 184,622; actual number of copies of single issue published nearest to filing date: 226,101. 10D. Free distribution by mail, carrier, or other means of samples, complimentary, and other free copies: average number of copies each issue during preceding 12 months: 2,530; actual number of copies of single issue published nearest to filing date: 1,680. 10E. Total distribution (sum of C and D): average number of copies each issue during preceding 12 months: 187,152; actual number of copies of single issue published nearest to filing date: 227,781. 10F. Copies not distributed. 10F1. Office use, left over, unaccounted, spoiled after printing: average number of copies each issue during preceding 12 months: 7,348; actual number of copies of single issue published nearest to filing date, 32,219. 10F2. Return from news agents: average number of copies each issue during preceding 12 months: 0; actual number of copies of single issue published nearest to filing date: 0. 10G. Total (sum of E, F1 and 2 — should equal net press run shown in A): average number of copies each issue during preceding 12 months: 194,500; actual number of copies of single issue published nearest to filing date: 260,000.

11. I certify that the statements made by me are correct and complete. Larry R. Driscoll, Business Manager.

Take Halley's Home

Astrophotography: A Step-by-Step Approach

Robert T. Little, Bausch & Lomb
Foreword by Isaac Asimov



Published in time to capture Halley's Comet, *Astrophotography* features everything the beginner needs to know to produce superb photographs of the skies. This lavish, full color guide takes the reader one step at a time from the basic techniques — with and without a telescope — to deep-sky and high-power photography.

Emphasizing the use of modern color films, amateur astrophotography pioneer Robert Little shows how to take spectacular shots of • constellations • comets and meteors • lunar and solar eclipses • Venus, Mars, Jupiter, and Saturn • nebulae, galaxies, and more. And the author's own breathtaking color photographs illustrate in stunning detail what amateurs can do by following his simple, jargon-free instructions. *A Selection of the Astronomy Book Club.*

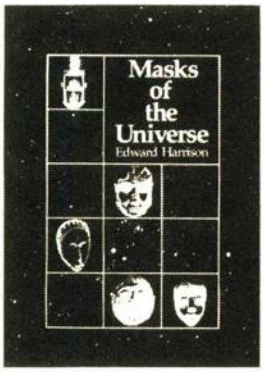
"Robert Little is, in my opinion, the most knowledgeable person in the United States in matters concerning the techniques of amateur astrophotography . . ." —*Isaac Asimov*

October 1985 96 pages 50 color photographs
ISBN: 0-02-948980-6 $19.95

Also of interest . . . a mind-stretching look at our perceptions of the cosmos

Masks of the Universe

Edward Harrison,
University of Massachusetts



To the ancient Greeks, the universe consisted of earth, air, fire, and water. To Saint Augustine, it was the Word of God. And to modern cosmologists, it's nothing more than a dance of atoms and waves.

But which is the *real* universe? All and none, says Harrison in this thought-provoking history of the diverse masks man has placed on the face of the universe. He shows how every universe has been the ultimate Universe — until a better one came along. And he asks: If our own mask of the universe is crumbling, what new vision of reality will replace it? *A Main Selection of Library of Science and Astronomy Book Clubs.*

October 1985 306 pages illus. ISBN: 0-02-948780-3 $18.95

To charge by phone to your VISA or MasterCard call toll-free
1-800-257-5755
(In NJ, AK, or HI dial direct 1-609-461-6500.)

At bookstores or order from the Publisher. Send check or money order plus sales tax where required to:

Macmillan Publishing Company
866 Third Avenue, New York, N.Y. 10022
Att: David Loiterstein

Edelman's

Hours Mon. - Fri. 9 - 5:30 EST

Full line of accesories in stock!

- **Free Freight**
- **Fantastic Prices - No hidden charges or gimmicks!**
- **Fast Computerized service!**
- **Huge inventory! Over 6 million dollars!**

Free Freight

CELESTRON

Super Polaris C8

(SP-C8)

Celestron took the C8 with 6×30 Finder and included it | with the Polaris mount, which puts you on the leading edge. Precise Worm Gear Drive, slow motion controls, Polar Alignment telescope with Illuminated Recticle and sliding counterweight with quick release. When coupled with the Sky Sensor, 757 objects become available at the touch of a button!

CQ11025	SPC8 w/mount & tripod	**$799.95**
CQ11024	SPC8 Starbright and special coatings	**$1199.95**

Super C8 'Plus'

With Starbright & Special Coatings!

Famous black C8 with all standards and "plus" accessories offered! Don't be fooled by others, ours are Celestron coated & certified, in stock and ready to ship at our fabulous no hassle prices!

CQ93501	tripod	**$209.95**
CQ936556	wedge'	**$59.95**

OUR PRICE

$1,199.95

Sky Sensor

For All Super' Polaris Models!

Sky Sensor gives 757 celestial objects at a touch of a button when coupled with the Super Polaris Mounts. this Mini Astro Computer can interface with RS232C home computers. Includes dual pulse motors.

CQ93797 .... **$379.95**

Super Polaris Reflectors and Refractors

	Super Polaris 80mm Refractor (SPC80)	
CQ21024		**$649.95**
	Super Polaris 80mm Refractor Flourite (SPC80F)	
CQ21024		**$1114.95**
	Super Polaris 6". Reflector (SPC6)	
CQ21001		**$699.95**

Free Freight

BUSHNELL

The Criterion 4000

The Compact 7"×7"×14"× weighs 10lbs. and includes Finderscope with 2 Oculars, adjustable legs, 1200mm effective focal length and Electrical Clock Drive

BU616400	Astro-clockdrive	**$444.95**
BU616410	Telephoto 1200mm F/12	**$279.95**
BU616440	Spotting Scope	**$299.95**

The C90's

Terrestrial Spotter

Telephoto Lens - Telescope

Big Eye: Ideal for field use. Image correct includes 30mm (33×) eyepiece, porro & case.

CQ51100 Big Eye C90 .... **$319.95**

Spotter: Nice for field and planetary use. Includes 18 & 30mm .96 eyepieces & 5×24 finderscope.

CQ51102 Spotter **$329.95**

Sportview & Banner Telescopes

Free Freight

BU785600	Sportview Expo 1 60mm	**$54.90**
BU785400	Banner Astro 155×60mm	**$61.90**
BU785500	Banner Astrc 280×60mm	**$72.90**
BU785100	Astro 900×69mm	**$97.90**

Criterion Large Objectives

BU61600	6000 Astro	**$699.95**
BU616800	8000 Astro	**$819.95**

Celestron & Cometron Telescopes

Celestron Firstscope 80	CQ21023	**$389.95**
Cometron CO40	CQ31014	**$89.95**
Cometron CO50B	CQ31009	**$299.95**
Cometron CO60G	CQ31002	**$139.95**
Comet Catcher Jr.	CQ31023	**$224.95**
Cometron Eq. Refractor	CQ31005	**$279.95**
Cometron Reflec. CO114	CQ31006	**$369.95**
Cometron Skywatcher CO62	CQ31001	**$224.95**
Cometron Skyscanner	CQ21021	**$299.95**

Celestron Giants

Perfect For Comet Use!

Perfect for dark sky viewing of comets, Nebulas and galaxies. Large fully coated 80mm objectives, tripod mount adapter, deluxe case & straps, center focus.

CQ71100	11×80 Giants	**$214.95**
CQ71101	20×80 Giants	**$224.95**
CQ71102	30×80	**$229.95**

Deluxe 20×80 Binoculars - the finest Astro Binoculars multicoated with slide mounting rail

CQ71103 .... **$339.95**

Leitz TRINOVID

"Perhaps the best pair of binoculars on the market!"

Audubon Magazine

Full Size - Green Rubber Armored

LT040238	7×35 BA special	$298.77
LT040234*	7×42 BA	$449.77
LT040235*	8×40 BA	$551.90
LT040236*	10×40 BA	$573.90

**You get $50 back from the factory on these items*

Compact Mini Black Rubber Armored

LT040309†	8×20 BCA	$224.90
LT040310†	10×25 BCA	$233.90
Leitz Full Size	Leather case	$41.90
Leitz Compact	Leather case	$18.90

†You get $25 back from the factory on Mini items.

Edelman's

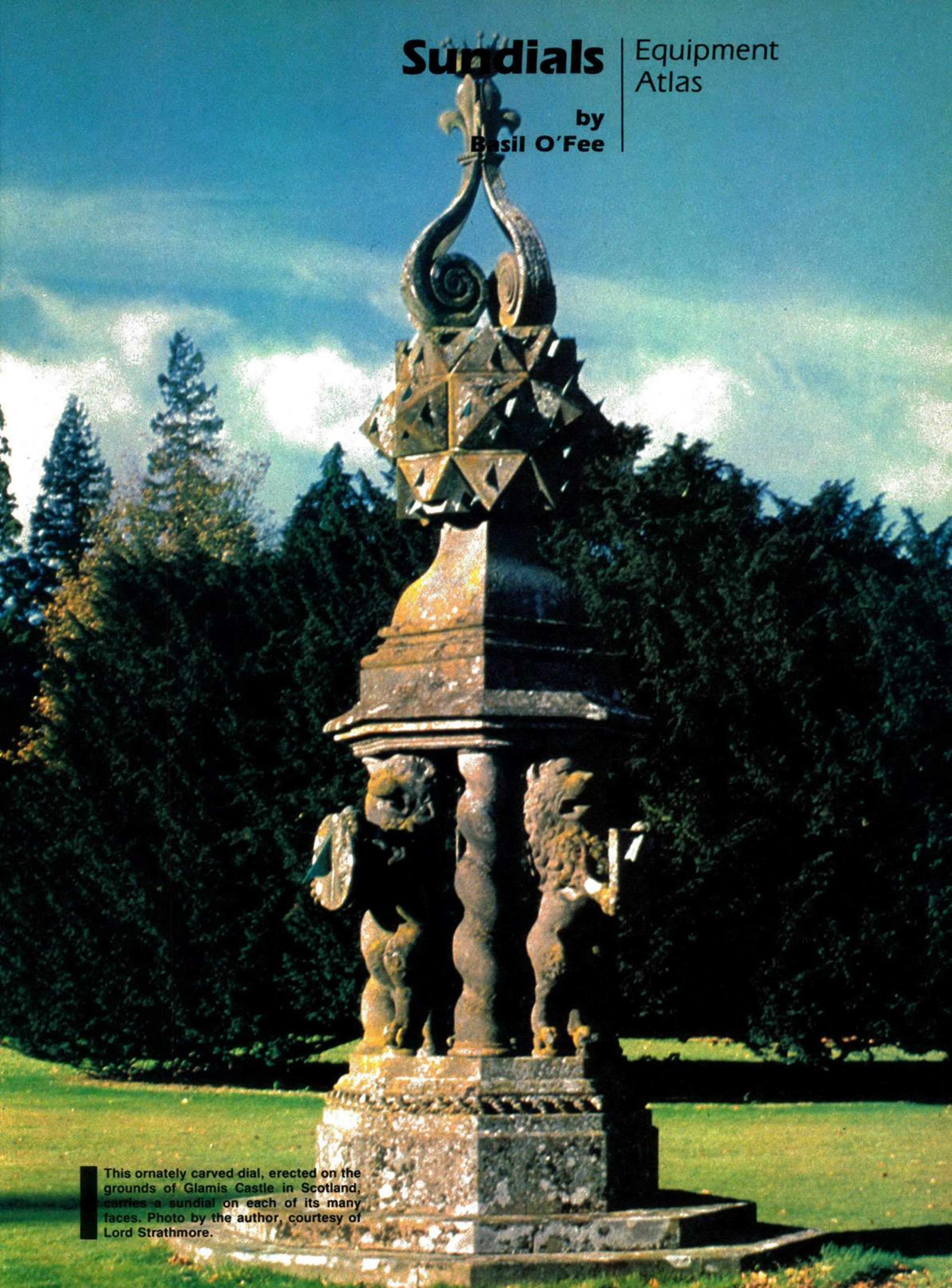
Box 2156 Warminster Pa. 18974
215-322-8599

No Hassle Free Freight policy! Mention this Ad get Freight Free any where in the U.S.! Visa & Mastercard accepted (add $2.75) COD (add $2.75) Cash & Certified checks only

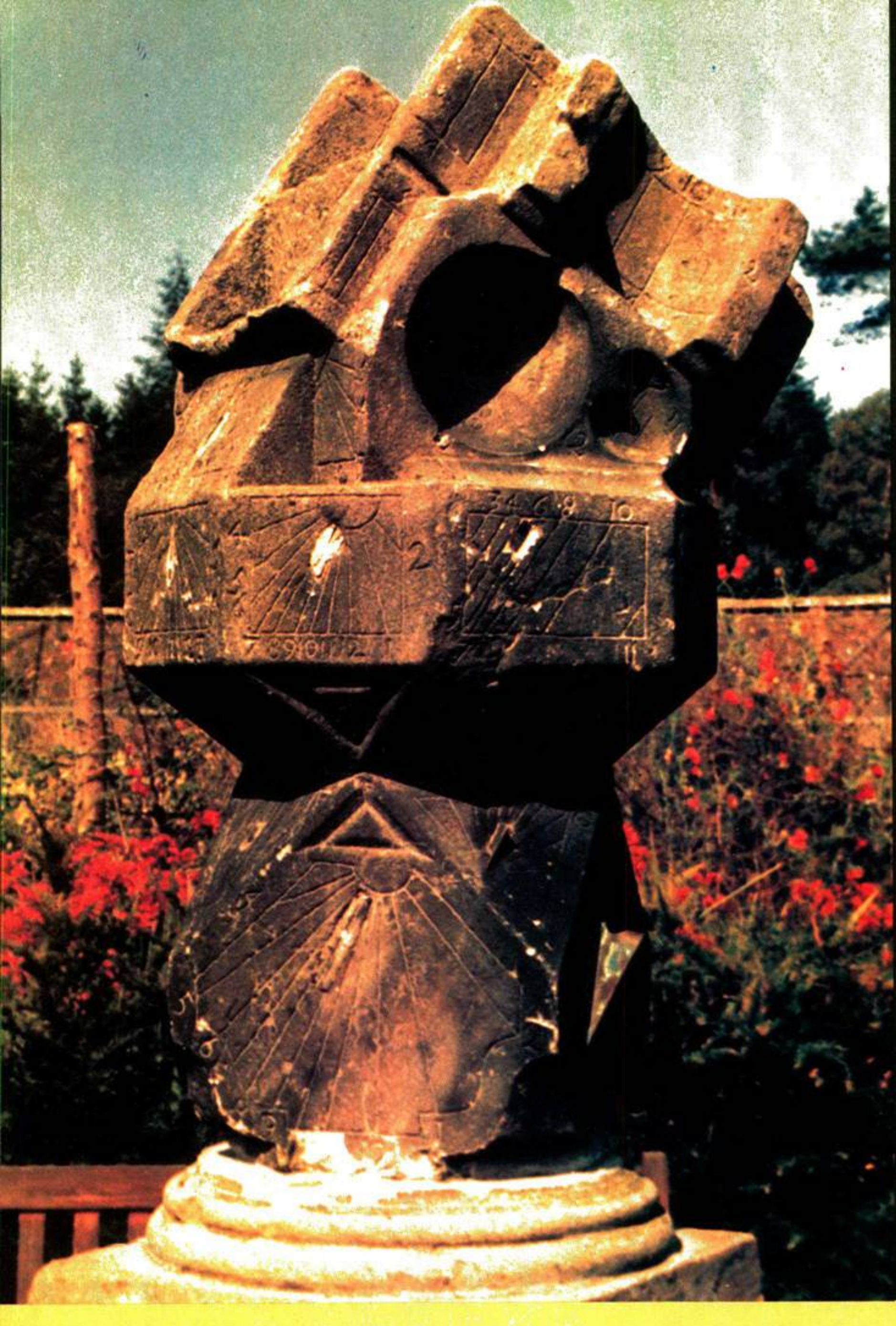
VISA | **Hours Mon. - Fri 9 - 5:30** | MasterCard

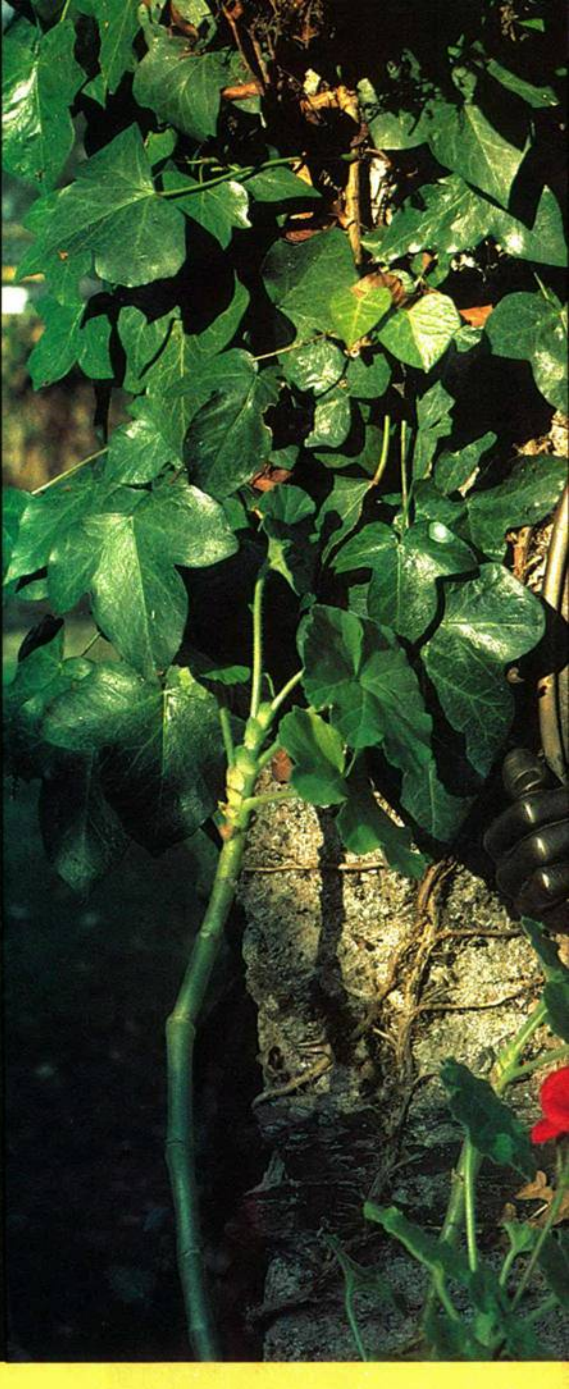
Sundials

by Basil O'Fee



This ornately carved dial, erected on the grounds of Glamis Castle in Scotland, carries a sundial on each of its many faces. Photo by the author, courtesy of Lord Strathmore.





Above left: Another Scottish castle, another multiple dial; this one is located on the grounds of Culzean Castle in Ayrshire. There's hardly an unused square inch of stone on the entire dial! Photo by Horace H. Harrison. Above right: "The Clown," a vertical dial for south-facing walls created by Andre Wallace. Photo by the author.

It was my amateur interest in astronomy that set me up for my current fascination with sundials, and I doubt I'm alone in this. I wonder how many other stargazers have put a dial in their backyards — or would if they could find one that looked reliable.

The origins of sundials are lost in history. Certainly the Babylonians and ancient Egyptians used them. It was the Moors in the Middle Ages, however, who took the important step of tilting the gnomon (or indicator) toward the North Star and thereby improved the instrument greatly. Yet that period — perhaps the sundial's finest — was also its swan song, for mechanical clocks soon took over timekeeping.

But sundials are delightfully simple instruments that need little or no maintenance. They perform their function faultlessly year after year — so long as it's sunny. "A clock may mistake in the hour of the day / But the orb of the Sun never goeth astray," claims one sundial inscription. (Neither Casio nor Seiko were the first to invent the solid-state clock!) Indeed, many sundials were originally erected to correct the eccentricities of early clocks and watches.

Sundials don't bother with cogs, weights, springs, counterbalances, pendulums, quartz crystals, or batteries. No ticks, hums, or electronic displays here. In truth, the sundial's moving parts work on a much grander scale. The simple dial manages to capture and tame colossal celestial movements and seasonal variations of the Earth and Sun. No watchmaker is needed to maintain the regularity of their proper motions; year after millionth year, for countless summers and innumerable dawns, the Earth and Sun have rolled through space with fine precision. The humble sundial taps this celestial harmony and ties itself into the cosmic equilibrium.

Surveying the contemporary sundial scene, however, it is dismaying to realize how scarce quality sundials are. Mass production and the garden ornament industry — creators of those pink flamingos and little lantern-bearing jockeys — have compromised the integrity of the commercial sundial. Many sundials are poorly made and most are designed

8
9
10
11
12
1
2
3
4
5
6

for latitudes other than where they are used. These and other inaccuracies mean that most of the sundials you see are seriously inaccurate. Typical scenario: one walks up to a sundial, checks it against a watch, finds the two don't agree, and mutters, "The silly dial's wrong. Oh, well, what do you expect?" And the sundial's reputation of inaccuracy is reinforced once again.

If you are thinking of installing a commercial sundial, you *can* find quality dials for sale if you look hard enough. And for many lower-quality dials, simple adjustments can recapture some of the accuracy lost in their design.

As mentioned earlier, the gnomon on a sundial should point to the north celestial pole. When the gnomon lies parallel to Earth's axis, its edge will act as a mini-axis around which the Sun appears to rotate at a constant rate. Delineating the hour lines then becomes an exercise in applied geometry; their exact placement depends on the orientation of the dial-face onto which the gnomon's shadow falls.

The face of the dial can be horizontal (as is usual), vertical (for wall dials), or equatorial (aligned to the equator). These are the simplest cases, but in fact a dial can be made from anything which casts a shadow onto a surface that can be marked with lines to tell the hours.

Every sundial, commercial or homemade, needs to be aligned with the local meridian. Finding north accurately, however, can be more perplexing than you'd think. A Boy Scout compass will suffice, providing you know the local magnetic deviation and there are no large ferrous metallic objects (such as cars) nearby. More reliable — and definitely more in the spirit of the thing — is using the Sun's shadow to locate true north.

The easiest method is to drive a thin metal shaft (a curtain rod, say) into a flat expanse of ground measuring several feet across. True up the shaft to vertical with a plumb bob and then carefully strike a circle around the rod two or three feet in diameter. On a sunny morning, note where the shadow of the rod's tip just intersects the circle. Mark the spot very carefully. Then in the afternoon, mark where the shadow's tip crosses the circle again. Bisect the angle that the two marked points form with the vertical rod and you'll have a true north-south line — and you will have done it the same way the Babylonians did.

The next step is determining if the dial was made for your latitude. Measuring the angle that the gnomon makes with the dial plate tells you what latitude the dial was originally designed for. On a horizontal dial, the gnomon angle should equal the

latitude angle it is used at, while on a vertical south-facing dial, the gnomon's angle will equal what is known as the co-latitude (90° minus the latitude). Should the built-in latitude of the dial you want differ from your own latitude, you can restore the dial to accuracy simply by tilting the whole thing up or down the appropriate number of degrees so that its gnomon points to the pole.

This procedure works if the dial is computed correctly, but you should never assume this. Knowing the dial's intended latitude from the gnomon angle, compute a few of the hour lines yourself (see the box below). If the dial's lines fall where your calculations show they should, the dial is properly made. If they don't match, forget the dial in question — it's a waste of money and you'd do better to design one yourself. (For some ideas, see the list of readings on page 51.)

For the perfectionist, quality dials are often handmade. Books show many fascinating designs and there's ample room for innovation. Nontraditional styling can inject much new interest into

Sundial Makings

It's not hard to lay out a sundial for your own location. Start by drawing up a table of hour angles for the Sun. For example, at 6 a.m. and 6 p.m., the Sun lies six hours (90°) off the meridian; at 7 a.m. and 5 p.m., the Sun is five hours (75°) off the meridian; and so on.

Then decide whether you want a horizontal or vertical sundial; look up your latitude (try the public library if you don't know it) and use the appropriate formula (below) to calculate the settings. The noon line acts as your "zero" reference.

For a horizontal dial, the basic equation for each line is:

$$A = \arctan(\sin L \times \tan H)$$

where A is the angle, L is your latitude, and H is the Sun's hour angle in degrees for the time in question (remember that one hour = 15°). For example, on a dial at latitude 34°, the 10 a.m. and 2 p.m. lines (hour angle = 30°) each lie at an angle of 18° to the noon line. Hour lines to the west of the noon line mark the morning hours and lines to the east mark afternoon hours. On a horizontal dial, the angle between the gnomon and the dial plate is equal to your latitude, the hour lines are symmetrical about the noon line, and the vertices of the angles lie at the noon line's south end.

For a vertical dial facing directly south, the equation is very similar:

$$A = \arctan(\cos L \times \tan H)$$

where the symbols remain the same as in the previous equation. On a vertical dial, the angle between the gnomon and the dial plate is equal to 90° minus your latitude, and the hour lines have their vertices at the upper end of the noon line.

Nendrum Sundial in Northern Ireland is an ecclesiastical dial dating from the early Middle Ages that has been restored and re-erected. Photo by the author, courtesy of the Northern Ireland Department of the Environment.

Sundial Sayings

Carpe Diem. (Seize the day.)

Festina lente. (Hasten slowly.)

Ita vita. (So goes life.)

Time is Mother Nature's way of not letting
everything happen all at once.

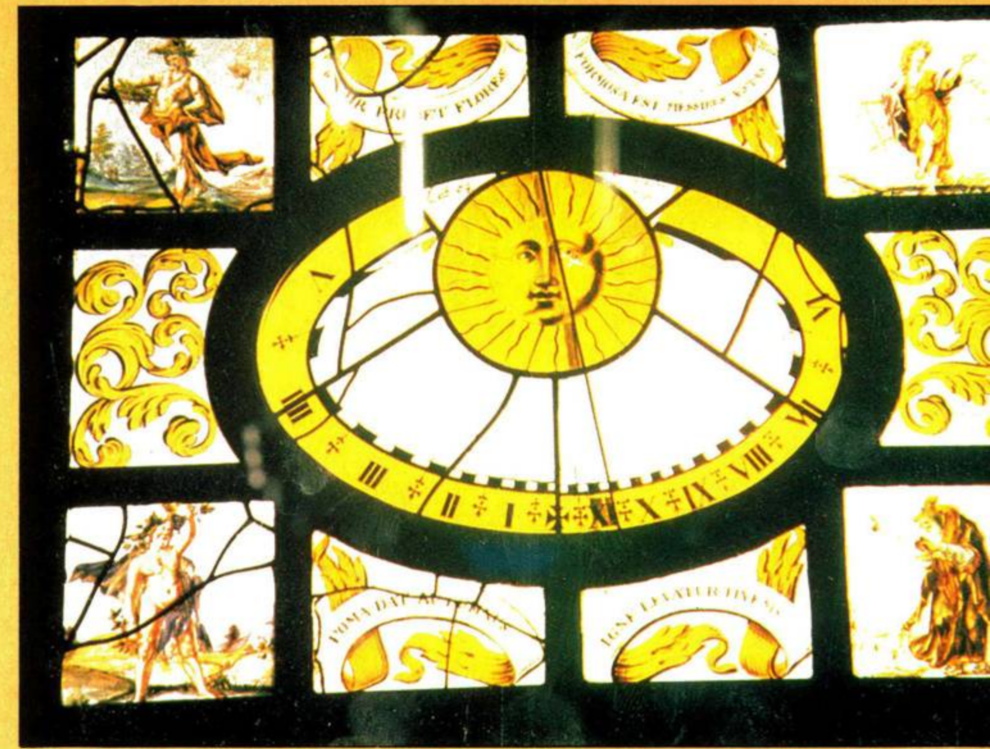
Time wastes us, our bodies, and our wits;
we waste time, so time and we are quits.

I am a sundial and I make a botch,
of what is done far better by a watch.

I count only the sunny hours.

Use 'em, don't count 'em.

One of these will be your last.



This leaded-glass window dial, built in 1669, is at Tong Hall, Bradford, England. Photo by the author, courtesy Dr. A. Somerville.

a traditional design, one example being a wall dial called "The Clown" that was made by Andre Wallace, an English sculptor. W.G. Bennoy produced an optical dial that indicates time by the movement of focused light. A large analemmatic dial can be laid out in such a way that your own shadow tells the time when you stand on the right spot.

Dials can be painted on windows or even indoors with sunlight "piped in" using a mirror. A mirror dial can display a circle of reflected sunlight that moves gracefully across a conveniently calibrated ceiling. In the 17th and 18th centuries, a tradition developed in which multi-faced obelisks were erected with sundials on each of their many fancifully-carved faces. Surprisingly, this tradition was particularly popular in cloudy Scotland!

A special case of the equatorial sundial, the armillary sphere, provides an interesting and impressive display. Whether frugal in design or extravagant, these dials model the astronomically-significant lines of the Earth such as the equator, the axis, the tropics, and the meridians. They are usually built in such a way that time is told on the lower half of the equatorial, while the upper part casts a perplexingly interwoven display of light and shadow.

Of course, sundials show only local solar time, which is two removes or more away from the mean solar time indicated by everyday clocks. The first discrepancy is caused by "the equation of time," the fact that the Sun's apparent motion across the sky isn't the same from one end of the year to the other due to Earth's elliptical orbit. In early February, for example, the Sun is almost 14 minutes late, according to clock time, and in early November it runs over 16 minutes fast. The error also has two lesser extremes, in mid-May when the Sun is 4 minutes fast and late July when it is 6 minutes slow.

The second discrepancy comes from the fact that few sundials are erected at the same longitude as the local standard time zone's meridian. If the dial lies to the east of the zone meridian, the Sun crosses the dial's meridian before crossing the zone's, so the dial is always "fast." The converse is true when the sundial is west of the standard meridian. Since the error remains constant throughout the year, it is easy to allow for. Just work out the longitude difference in degrees between the dial's location and the standard zone meridian, then divide that number by 0.25; the result is the error in minutes. (Standard zone meridians across North America are 75° west longitude for eastern time, 90° for central, 105° for mountain, and 120° for Pacific.)

An additional discrepancy crops up when daylight-saving time is in effect. Fortunately, this always amounts to an error of whole hours and thus is easy to adjust for.

But a sundial needn't indicate merely the correct local time. Much more fun can be had! At the Old Royal Observatory in Greenwich, England, there's a series of three wall dials that illustrates some alternatives. One dial tells the number of hours elapsed since sunrise (the old Babylonian timekeeping system), the second shows the hours since yesterday's sunset (the old Italian system), and the third shows the unequal or "planetary" hours (a system derived from a period when people divided daylight into 12 hours but took no account of the seasonal differences in the length of day and night).

Sundials can also exhibit the date, show the sign of the zodiac, and display where the Sun is at the moment. A dial can show the Sun's azimuth and altitude in the sky. And why stop there? Wouldn't it also be fun to have dials that read the time in various parts of the world? The possibilities are limited more by one's imagination than anything else.

Basil O'Fee writes, "At present, I'm working on establishing an outdoor sundial collection as a tourist and leisure attraction. I'd be happy to hear from any sundial enthusiasts or innovators worldwide." His address is 31 Knockmore Park, Bangor, Northern Ireland BT20 3SL.

Sundial Readings

Adzema, Robert and Mablen Jones. *The Great Sundial Cutout Book*, Hawthorn Books, 1978. Has more innovative sundial designs than any other book published in recent years.

Burnham, Robert. "Building a Sundial," ASTRONOMY, March 1980. Survey of sundial types.

Cousins, Frank. *Sundials*, Pica Press, 1969. Thoroughly illustrated with clear line diagrams and photos; excellent general reference book but somewhat hard to find.

Mayall, R. Newton and Margaret W. Mayall. *Sundials*, Sky Publishing, 1973. Handy work with many illustrations, a few in color.

Rohr, Rene. *Sundials: History, Theory, and Practice*, University of Toronto, 1970. Hard to find, but contains good historical material and many illustrations.

Stoneman, Milton. *Easy-to-Make Wooden Sundials*, Dover, 1982. Simple how-to book with cutout templates.

Waugh, Albert E. *Sundials: Their Theory and Construction*, Dover, 1973. Good general reference book; still in print.

Meade & Celestron
LUMICON Carries a full line of telescopes & accessories. Fast Delivery, competitive prices. Both Catalogues $3

LUMICON FOR HIGH PERFORMANCE

BEST TO PHOTOGRAPH COMET HALLEY

Wide-angle **piggyback** photography is best, because of Comet Halley's long 10-30° tail. 50-200mm focal length lenses will yield the best photos of Comet Halley. Use a 10-20 minute photo at f/2.8.

Celestron C60E Equatorial Refractor, set up for piggyback photography (shown with camera and 135mm lens, not included). Complete photo-visual telescope system with 60mm f/15 guidescope 36X & 90X eyepieces, motor for **both** Northern & Southern hemisphere, equatorial mount, adjustable tripod, quartz drive corrector and camera platform ($730 list), only **$498**. Supplies limited. Cable release **$10**. 12mm illuminated reticle guiding eyepiece, fits 0.96 and 1¼" **$79**.

48mm COLORED FILTERS

Upgrade to 48mm filters! All are multi-coated

UV, Green, Yellow, Orange, Red	**$14 each**
48mm h-Alpha Pass (640nm cut-off)	**$30**
48mm Minus Violet (420nm cut-off)	**$20**
48mm High perform blue, 90% trans.	**$30**
UV-370 U-Band, 320-420nm bandpass	**$15**
48mm Polarizer (2 make variable density)	**$25**
Set 9 ea. 48mm filters ($175 list)	**$148**
2"/1¼ adapter threader for 48mm filters	**$20**

H-ALPHA PASS FILTER

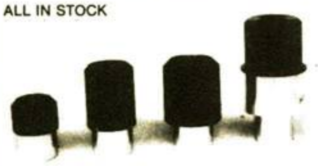
Yields spectacular contrast gains in B&W photography with telephoto lenses. Yields pinpoint star images. Superb with hypered 2415. For color, use the Minus Violet (MV) Filter.

Specify Lens Size	H-Alpha	(MV)
46, 48, 49mm	$35.00	$29.00
52, 55, 58, 62mm	$45.00	$35.00
67, 72, 77mm	$52.00	$45.00
82mm	$55.00	

Hypered 2415 film, 36 exp . . . **$9.95** . . . **3/$27**

TELE VUE™ EYEPIECES USE THE BEST!!

ALL IN STOCK



7.4, 10.4, 13, 17, 21, 26mm Plossl, 50°	**$80**
1.8x or 2.5x Tele Vue Barlow Lens	**$80**
32mm Plossl, widest true field in 1¼"	**$95**
55mm 2" Plossl, widest possible field	**$175**
15mm Wide-Field, 1¼" eyepiece, 65°	**$110**
19mm Wide-Field, 1¼" eyepiece, 85°	**$125**
24mm Wide-Field, "superb", 65°	**$140**
32mm Wide-Field, 2" eyepiece, 65°	**$210**
40mm Wide-Field, "awesome", 65°	**$265**
4.8mm Nagler, 82° field	**$140**
7mm Nagler, 1¼" eyepiece, 82° field	**$175**
9mm Nagler, 82° field, "the best"	**$210**
11mm Nagler, 82° field, 1¼" or 2"	**$225**
13mm Nagler, 82° field, 1¼" or 2"	**$235**

NEW! ENHANCED SILVER DIAGONAL MIRRORS BOOST TELESCOPE PERFORMANCE

LUMICON 1.3" & 3.1" enhanced silver diagonal mirrors & 2" star diagonal.
The new LUMICON diagonal mirrors have a special enhanced silver coating with a protective overcoating for long life. Visible reflectivity is 98-99% compared to 86-89% for standard aluminum coated mirrors. The extra 10-12% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

1.32" . **$29.95** 1.52" . **$34.50** 1.83" . **$39.50**
2.14" . **$47.50** 2.60" . **$59.50** 3.10" . **$79.50**
4.25 . **$129.50**

ENHANCED SILVER STAR DIAGONAL

90° star diagonals with above enhanced silver mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

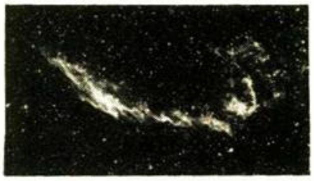
1¼" (1.32" mirror)	**$79.50**
2" (1.83" mirror)(see photo above)	**$129.50**

LUMICON FILTERS STOP LIGHT POLLUTION

UHC Filter™

ULTRA HIGH CONTRAST

The **LUMICON UHC FILTER** is specially designed astronomy in areas of severe light pollution or for viewing very faint nebulae at any location. **UHC** stands for **U**ltra **H**igh **C**ontrast and this filter is guaranteed to yield a higher visual contrast on planetary and emission nebulae than any other filter at any price. 24nm visible bandpass, 482-506nm.



"I CAN SEE THE VEIL NEBULA!"
Rich Zepernick saw the Veil Nebula for the very first time with a LUMICON UHC Filter. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings. I don't know how I managed without these filters."*
Zepernick, Cresskill, NJ

For optimum astronomy, use either the **LUMICON DEEP-SKY Filter** or the **LUMICON UHC Filter**

DEEP-SKY FILTER™

The **LUMICON DEEP-SKY FILTER** improves your view of **all** deep-sky objects including galaxies and comets. It removes natural and man-made light pollution and yields 3-6x contrast gain for nebulae and 1-3x contrast gain for clusters and galaxies. It is ideal for **both** visual use and B&W or color photography. This gentle filter yields the most natural view of any LPR filter available today. 90nm visible bandpass. 442-532nm. H-Alpha 656nm transmission = 80-95%.

	Standard	Premium*
1¼" LUMICON DEEP-SKY Filter threads into most 1¼" eyepiece		**$79.50**
48mm LUMICON DEEP-SKY Filter (1.75" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS		**$119.50**
2" LUMICON DEEP-SKY Filter (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography	**$99.50**	**$119.50**
72mm LUMICON Giant DEEP-SKY Filter (62, 67, 77mm adapter, $8)		**$299.50**
1¼" LUMICON UHC Filter threads into most 1¼" eyepieces	**$79.50**	**$99.50**
48mm LUMICON UHC Filter (1.75" aperture) fits most 2" eyepieces	**$149.50**	**$189.50**
Set of Both 1¼" **DEEP-SKY** and **UHC Filters** (Save 11%)		**$159.50**
1¼" H-BETA Line Filter 9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae)		**$89.50**
48mm "Horsehead Nebula" H-BETA Line Filter		**$169.50**
Oxygen-III Filter for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm 0-III lines	**1¼" $99.50,**	**48mm $189.50**
Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm		**$6.95**
Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece		**$16.00**
Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece		**$20.00**

**Premium filters are selected best of the lot and typically have 5-10% higher transmission. Not always available. Include individually measured transmission data.*

DEEP-SKY ASTROPHOTOGRAPHY

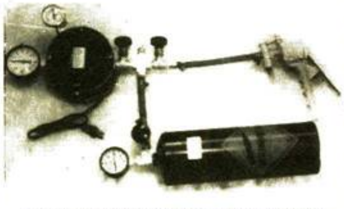
FILM HYPERSENSITIZATION KITS†

LUMICON HYPER-KITS™ yield 3-15X film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of nonflammable forming gas & hand-operated vacuum pump.

†Patent Pending

MODEL 100 HYPER-KIT for 35mm film, rolled-up. *Takes longer*, but it easy to use. Not recommended for 2415 . . . . **$225.00**

MODEL 300 HYPER-KIT sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds **$295.00**



MODEL 600 HYPER-KIT [See Photo] Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates **$325.00**

MODEL 1200 HYPER-KIT is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller . . . **$525.00**

Temperature controller for any HYPER-KIT **$59.50**

Electric Vacuum Pump **$280.00**

GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X eaiser guide-star selection, use 48mm filters, 360° camera rotation, large prisms fo bright guide-starts. *Specify Camera and Telescope type.*
U.S. Patent # 4,448,500

NEWTONIAN EASY-GUIDER™

Full aperature. Installs in secs. Specify 2" or 1¼".

NEWTONIAN EASY-GUIDER	**$149.50**
3X Relay Diagonal [See Photo]	**$69.50**
Illuminated reticle eyepiece system	**$69.50**

CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Dynamax-8. Includes 50mm achromatic lens for f/5.8 operation-3X shorter exposures! **Superb rich field viewing, too!**
CASSEGRAIN EASY-GUIDER **$199.50**

GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

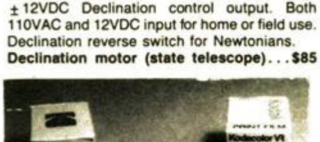
GIANT EASY-GUIDER	**$359.50**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20)	**add $79.95**
Premium ($119.50 list)	**$99.95**

WHAT DO YOU NEED?

1. **Illuminated reticle eyepiece . . . $69.50** Lumicon 12mm eyepiece system has adjustible L.E.D. illumiation, dual crosslines, battery pack.
2. Cable release for long exposures . **$9.95**

3. **LUMICON Quartz Drive Corrector . . $219** Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.

Declination motor (state telescope) . . . $85



HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography.

Film Type (35mm unless marked)	Exposures	Price
2415, Ultra-fine B&W, red sens	36	**$9.95**
VR200, fine grain color negs	12	**$9.95**
Fujichrome 400, "Excellent"	20	**$12.95**
SR1600, fastest of all, color negs	24	**$12.95**
5072, color slides from negs	36	**$6.95**
D-19 B&W Developer	1 gal.	**$6.95**

LUMICON®

2111 Research Dr. #5A, Livermore, CA 94550
For phone orders please call (415) 447-9570
LUMICON Products catalogue $2.
Foreign orders add 6% ($8 minimum)
California Residents add 6% tax.
Prices subject to change w/o notice
Hrs: M-F 9am - 5pm; Sat 11am - 3pm

Authorized Meade Dealer

Meade® TELESCOPES AT LUMICON

MEADE 2080/LX3 .... $1695

2080/LX3 System w/wedge & tripod ($2800 list)	$1695
2080/LX2 System w/wedge & tripod ($2450 list)	$1495
Multi-coated silvered optics, boost trans. 18%	add $149
#36 dual-axis drive corrector control box	add $99
#38 declination motor & clutch ($150 list)	add $99
Dew shield and accessory tray	add $89

2080/LX3
$1695
IN STOCK!
GET
READY
FOR
COMET
HALLEY

NEW! Quartz Drive Meade 2080/LX3

The Meade 2080/LX3 with built-in quartz electronic drive system is positively the highest performance 8" Schmidt-Cassegrain telescope system available today.

- ★ Certified diffraction-limited optical system
- ★ Built-in quartz microelectronic sidereal drive system
- ★ 8x50mm right-angle illuminated Polar viewfinder
- ★ Multi-coated prism star diagonal (99% transmission)
- ★ 25 ft. cord for field operation from a 12V car battery
- ★ 25 ft. cord w/ converter for 110VAC 50/60 Hz operation
- ★ Output jacks for illum. reticle eyepiece and map light
- ★ Equatorial wedge with compass, bubble level, micro metric azimuth control
- ★ Piggyback camera mount for effortless wide-field photography (**Best to photograph Comet Halley!**)
- ★ Audio cassette explains features, set-up, visual & photographic applications

FEATURES OF BOTH 2080/LX2 & 2080/LX3

- ★ Lifetime warranty on telescope, wedge, tripod
- ★ 8"f/10 Schmidt-Cassegrain optics, F = 2000mm
- ★ 20mm Research-Grade Erfle 1¼" eyepiece (100X)
- ★ 7mm Research-Grade Orthoscopic eyepiece (286X)
- ★ High transmission coatings on the front corrector lens
- ★ Ultraprecision 6" LX worm gear motor drive
- ★ Oversize 8.25" primary mirror benefits photography
- ★ Convenient fork mount with slow motion controls
- ★ Best overall mechanical stability of any 8" Cassegrain
- ★ Large right ascension & declination setting circles
- ★ Padded carrying case
- ★ Eyepiece rack
- ★ Lattitude scale and no-tool knob set
- ★ Adjustable height heavy duty tripod with eyepiece rack
- ★ Dew shield & accessory tray, optional **add $88**
- ★ Star map & finder cards for Messier objects
- ★ Red astronomer's night flashlight
- ★ **Optional:** Multi-coated/silvered optics boost transmission 18%, **add $149**

2120/LX3 10" System $2695

The 10" Meade 2120/LX3 collects 56% more light than an 8" telescope for significantly improved viewing and astrophotography. It has all the features of the 2080/LX3 (see above.)

Meade 2120/LX3 w/wedge & tripod ($4500 List)	**$2695**
Multi-coated/silvered optics boosts transmission 18% Highly recommended!	**$195**
#710 dew shield (10") Essential!	**$98**
#36 dual-axis drive corrector control box	**$99**
#38 declination motor and clutch	**$99**
LUMICON Giant EASY-GUIDER/Rich-Field viewer for f/4-f/10 operation (state camera)	**$359**

4" MEADE 2045 w/ table tripod ... $589

$589
IN STOCK!
IDEAL FOR
COMET
HALLEY

Meade Model 2045 — Advanced engineering and superb optical performance in a beautiful ultraportable system.

FEATURES OF THIS TELESCOPE

- ★ 4"f/10 Schmidt-Cassegrain optics, F = 1000mm
- ★ High transmission coatings on front corrector lens
- ★ Table tripod for easy polar alignment
- ★ 5X24 straight-thru finderscope
- ★ 1¼" right-angle star diagonal
- ★ 1¼" 25mm (40x) and 9mm (111x) eyepieces
- ★ Sturdy fork mount with setting circles
- ★ Manual slow motion controls
- ★ Star map & red astronomer's flashlight

HIGHLY RECOMMENDED OPTIONS

Model 43 drive corrector uses 12VDC ($120 List)	**$96**
See Meade 2080/LX2 options	
Wedge & field tripod as for 2080/LX2	**$298**
Dew shield	**$45**
Solar Filter	**$126**

80mm REFRACTOR $495

Model 310 ($700 list) **$495**

Excellent for both terrestrial & astronomical viewing 80mm (3.1") f/11 refracting telescope includes 1¼" focuser, 6x30mm finderscope, 36X and 100X 1¼" eyepieces, adjustable height tripod with accessory tray, and alt-azimuth mount with slow motion controls.

Model 320 ($900 list) **$630**

Identical to 310, but has equatorial mount with setting circles.

Quartz motor drive	**$169**
Basic camera adapter	**$32**
Easy-Guider (state camera)	**$149**

OPTIONS BOOST PERFORMANCE

LUMICON UHC Filter for nebulae. Standard 1¼"	**$79**
Prem 1¼", **$99**; Std 48mm, **$149.50**; Prem 48mm	**$189.50**
LUMICON Deep-Sky Filter, 1¼" Premium	**$79**
48mm Prem Deep-Sky	**$119.50, $99.95** w/ Easy-Guider
Adapter for viewing w/ 1¼" eyepiece	**$20**
Dust Covers. Keep optics clean. For 6"	**$16/pair**
8" **$20/pair;** 10" **$18;** 16"	**$24**
LUMICON Rich-Field Viewer (2080)	**$120**
LUMICON Newtonian Easy-Guider, 1¼" or 2"	**$149**
#122 2X Barlow ($60 list)	**$48**
Dual-axis drive corr. and elec. dec.: for 2080/LX2	**$298**
for Model 628, 826, DS-10 **$340** for DS-16	**$420**
Tele Vue 32mm Plossl 1¼" eyepiece	**$88**
LUMICON Cassegrain EASY-GUIDER for 2080/LX2 & /LX3 (state camera)	**$199**
Illuminated reticle eyepiece & battery pack	**$69.50**

All foreign orders add 6% ($8 minimum)
California residents add 6% tax
Prices subject to change w/o notice
Set Meade and LUMICON Catalogues $4
LUMICON, 2111 Research Dr., #5
Livermore, CA 94550
Call **(415) 447-9570** for information & orders
Store Hours: M-F 9am - 5pm; Sat 11am - 3pm
All telescopes shipped F.O.B. Livermore

8" f/6 NEWTONIAN $995

BEST VALUE!

IDEAL FOR COMET HALLEY

Model 826, 8" f/6 Telescope w/accessories

Model 628, 6" f/8 with motor drive ($1220 list)	**$750**
Model 628C, 628 w/2" focuser, 8x50mm finder ($1350	**$850**
Model 826C, 8" f/6 with motor drive, #680 2" focuser and 8x50mm finderscope ($1530 list)	**$995**

—Collects 78% more light than a 6" telescope.

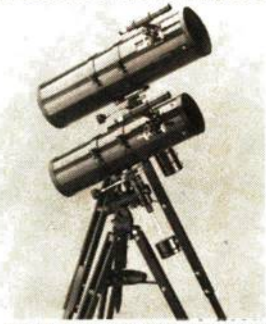
These Meade Deluxe Series reflecting Telescopes have superb image quality at low or high power. They include an equatorial mount with motor drive, pier, legs, setting circles, 1¼" rack & pinion focuser, 6x30mm finderscope, 25mm (48x) and 9mm (135x) 1¼" eyepieces, altitude and azimuth fine adjustments for polar alighment.

#43 drive corrector uses 12VDC ($120 list)	**$96**
#47M Dual-axis drive corrector & elec. dec.	**$340**
1¼" or 2" EASY-GUIDER (state camera)	**$149**

6" f/5 NEWTONIAN $695

IN STOCK!

IDEAL FOR COMET HALLEY



Models 6600 (6" f/5) & **8800** (8" f/4.5) telescopes

Model 6600, 6" f/5 Newtonian telescopes ($1100 list)	**$695**

—*Best performance & value; bright, wide views.*

Model 8800, 8" f/4.5 Newtonian Telescopes ($1400)	**$895**

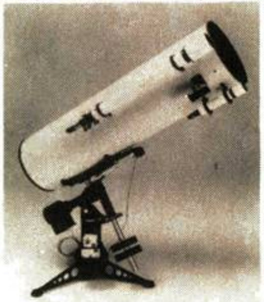
—*Collects 78% more light than a 6" telescope.*

These meade Professional Series reflecting telescopes yield superb rich-field viewing w/bright images. They include an equatorial mount w/adjustable tripod, setting circles, slow motion controls, 6x30mm view-finder, 1¼" focuser, 25mm & 9mm 1¼" eyepieces & accessory tray.

#784 Quartz motor & quartz drive corrector	**$169**
Basic camera adapter (for moon & planets)	**$32**
1¼" LUMICON Easy-Guider (state camera)	**$149**

16" f/4.5 NEWTONIAN $1995

GET READY FOR COMET HALLEY



Meade DS-16A with Accessories

The DS Series of 10" and 16" reflecting telescopes are ideal for deep-sky viewing and photography.

DS-10A, 10" f/4.5 with motor drive ($150 list)	**$995**

—Gathers 56% more light than an 8" telescope

DS-16A, 16" f/4.5 with motor drive ($3050 list)	**$1995**
Sealmaster ball bearings, highly recommended	**add $229**

—Gathers 400% more light than an 8" telescope

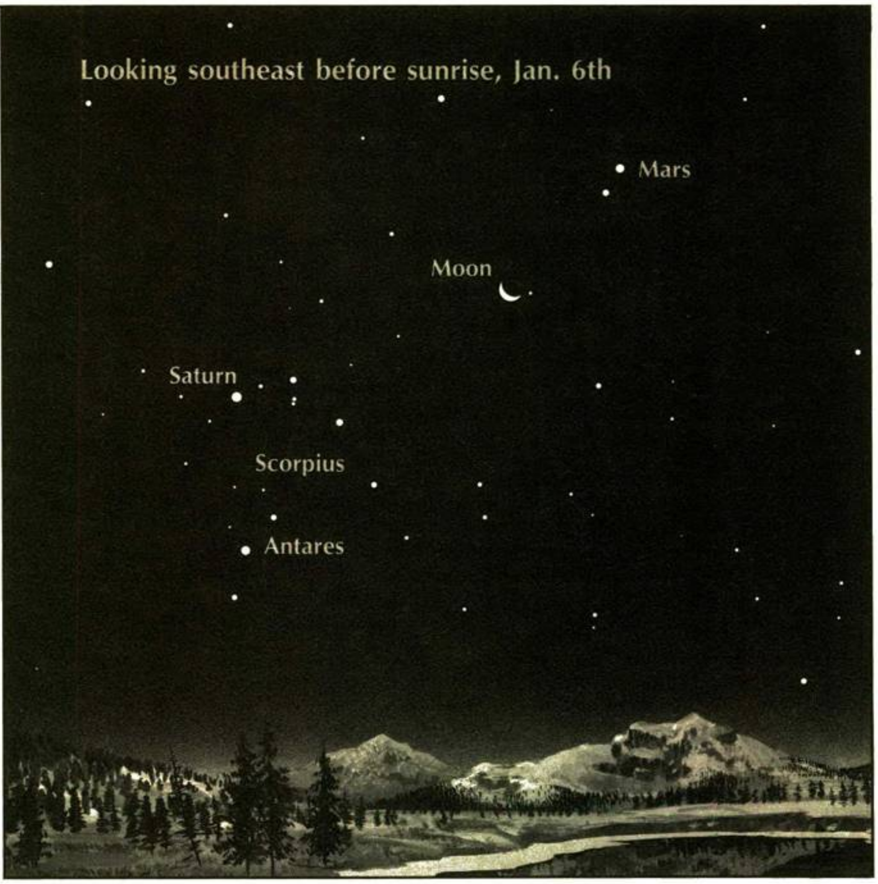
Both the DS-10A and DS-16A telescopes include an equatorial mount, #680 2" focuser, motor drive, setting circles and 25mm 1¼" eyepieces.

6x30mm finderscopes with brackets ($46 list)	**$39**
8x50mm finderscopes with brackets ($114 list)	**$89**
Sealmaster ball bearings for DS-16, **Recommended**	**$225**

LUMICON, 2111 Research Drive #5, Livermore, CA 94550 • (415) 447-9570

Halley's Show in the Evening Sky

by Fred Schaaf


Looking southeast before sunrise, Jan. 6th
Mars
Moon
Saturn
Scorpius
Antares

The Wanderers

Halley's Comet is visible in the western sky after sunset as the new year begins. During January, the comet will race inside the orbit of Venus as it heads toward the opposite side of the Sun from us. Each evening, therefore, we'll see it lower in the sky but brighter. Exactly how prominent Halley's Comet will become this month remains uncertain, however.

Halley may shine no brighter than fourth magnitude before it sinks into the Sun's afterglow by the last week of January. This would make it a difficult naked-eye object all month, and its tail might appear several degrees long only under very clear, dark skies or with the aid of binoculars.

Halley's altitude for 30° to 40° north latitude will decrease from 30° to 15° during the first half of January, when the Sun is 18° below the horizon (about 90 minutes after sunset); it is down to 1° by January 25th. The tail should be visible (at least in binoculars), extending almost straight up from the head.

During the evening of January 12th, the comet has its best conjunction with a solar system object — Jupiter — at this return. On that night, look for Halley with binoculars to the upper right of the Moon and Jupiter.

Like the comet, **Jupiter** is also departing the evening sky. It doesn't reach superior conjunction with the Sun until February 18th, however, and its magnitude −2 brightness will keep it visible after sunset into the early part of February. The brightest planet, **Venus**, isn't visible at all this month because it is in solar conjunction on January 19th.

On New Year's Day, −0.4 magnitude **Mercury** lies about 5° above the southeastern horizon half an hour before sunrise, but it will sink lower each succeeding day. By January 10th, the planet will be difficult to see. As Mercury disappears into the morning twilight, it leaves behind it two planets: Mars and Saturn.

For information on viewing the Moon, planets, and deep-sky objects with telescopes, see **The Backyard Astronomer**.

Mars rises first. Look for this ruddy, magnitude 1.3 planet in Libra several hours before morning twilight begins. On the 7th, Mars lies just north of the bright double star Alpha (α) Librae. By month's end, Mars' eastward motion brings it within 10° of Saturn.

At magnitude 0.5, **Saturn** outshines both Spica in Virgo and Antares in Scorpius — the latter star being about 8° away from the planet this month. In February, we'll witness the first of Saturn's three passes north of Antares.

The Starry Sky

Perhaps nowhere else in the sky do six bright constellations gather together the way **Orion**, **Canis Major**, **Canis Minor**, **Gemini**, **Auriga**, and **Taurus** do. If you observe under light-polluted skies or around Full Moon, look for configurations, or asterisms, of their brightest stars. Sirius, Procyon, and Betelgeuse, for example, are sometimes called the **Winter Triangle**. Asterisms may be small, like Orion's Belt, or as large as the Winter Triangle.

Still larger asterisms are formed from the first-magnitude stars of winter. One of these is the **Winter Hexagon**, which is formed by drawing a line connecting Aldebaran, Capella, Castor and Pollux, Procyon, Sirius, Rigel and back again to Aldebaran. At the center of the Hexagon is the first-magnitude gem Betelgeuse.

Dale Lightfoot caught this Perseid meteor near Slumgullion Pass in Colorado on August 12, 1985, with a 28mm lens, Ektachrome 400, and a 4-hour exposure at f/2.8.

Even veteran skywatchers are intrigued by star colors. These tints are usually quite subtle, so don't expect bright flashing lights! To many observers, Rigel appears distinctly blue while Betelgeuse tends to be ruddier than any other bright star. Capella's yellow hue is also quite noticeable. But is Sirius blue-white or just white? Is Procyon very slightly yellow? Whose orange is deeper, Aldebaran's or Pollux's?

And what about distance? How would the winter sky change if we could journey out toward these stars? First we would pass the brilliant but near neighbors, Sirius and Procyon. Next would be many more stars, including Pollux, Castor, and Aldebaran, which lie between 20 and 100 light-years away. The Hyades and Pleiades clusters and numerous other naked-eye stars, all 100 to 500 light-years away, would then fall behind us and disappear.

Traveling further we would find that a rich area of bright stars still remains. These are most of the stars of Orion, which

January's Night Sky

Last Quarter
January 3
2:47 p.m. EST

New Moon
January 10
7:22 a.m. EST

First Quarter
January 17
5:13 p.m. EST

Full Moon
January 25
7:31 p.m. EST

2nd Earth is closest to the Sun early this morning: 90.54 million miles.

3rd Last Quarter Moon is at 2:47 p.m. EST; the Moon will greatly interfere with the Quadrantid meteor display, which reaches peak activity today.

6th The Moon, Saturn, and Mars form a pretty group in the predawn sky.

8th The Moon is closest to Earth at 2:28 a.m. EST: 225,747 miles.

10th The Moon is New at 7:22 a.m. EST.

12th A crescent Moon lies to the left of Jupiter this evening, while Halley's Comet will be visible in binoculars to the upper right of both.

15th At 10:30 p.m., the Milky Way spans the sky from southeast to northwest, displaying the bright stars of winter to best advantage.

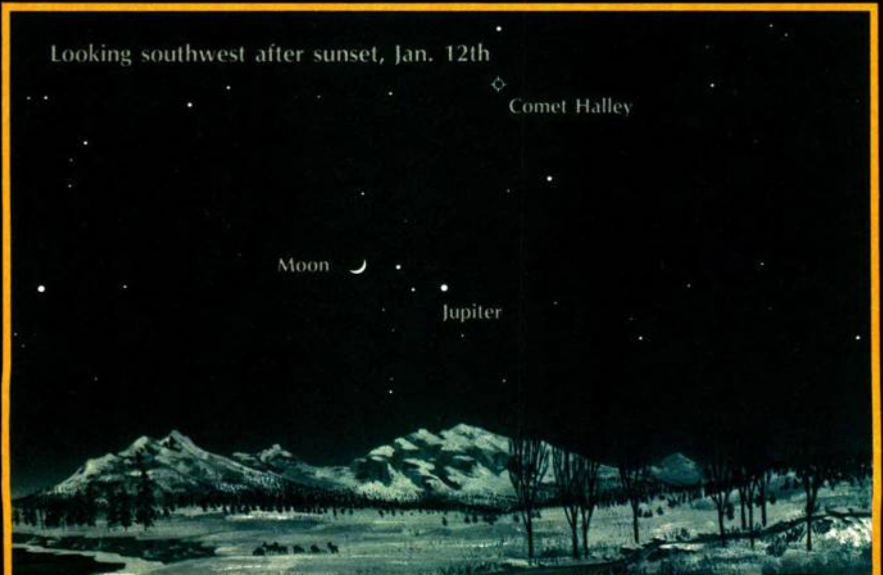
17th First Quarter Moon is at 5:13 p.m. EST.

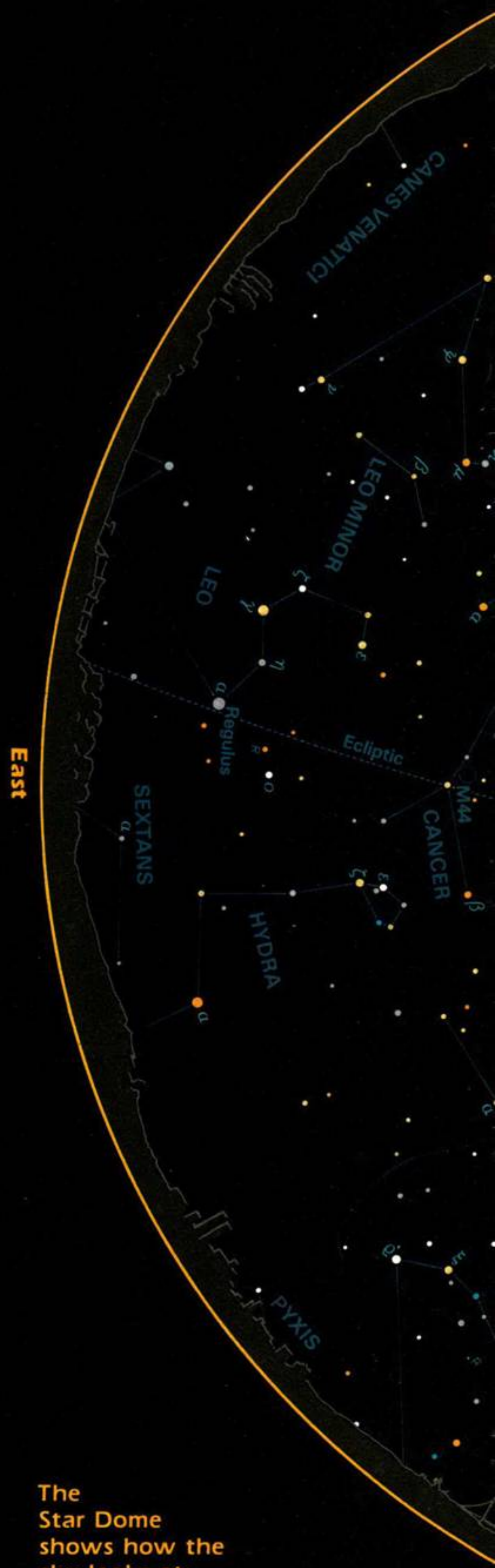
19th The Moon is farthest from Earth at 8:23 p.m. EST: 251,481 miles. Venus is in conjunction with the Sun; it passes from the morning sky into the evening but won't be visible there until March at the earliest.

20th How long can you keep Halley's Comet in view?

25th The Moon is Full at 7:31 p.m. EST.

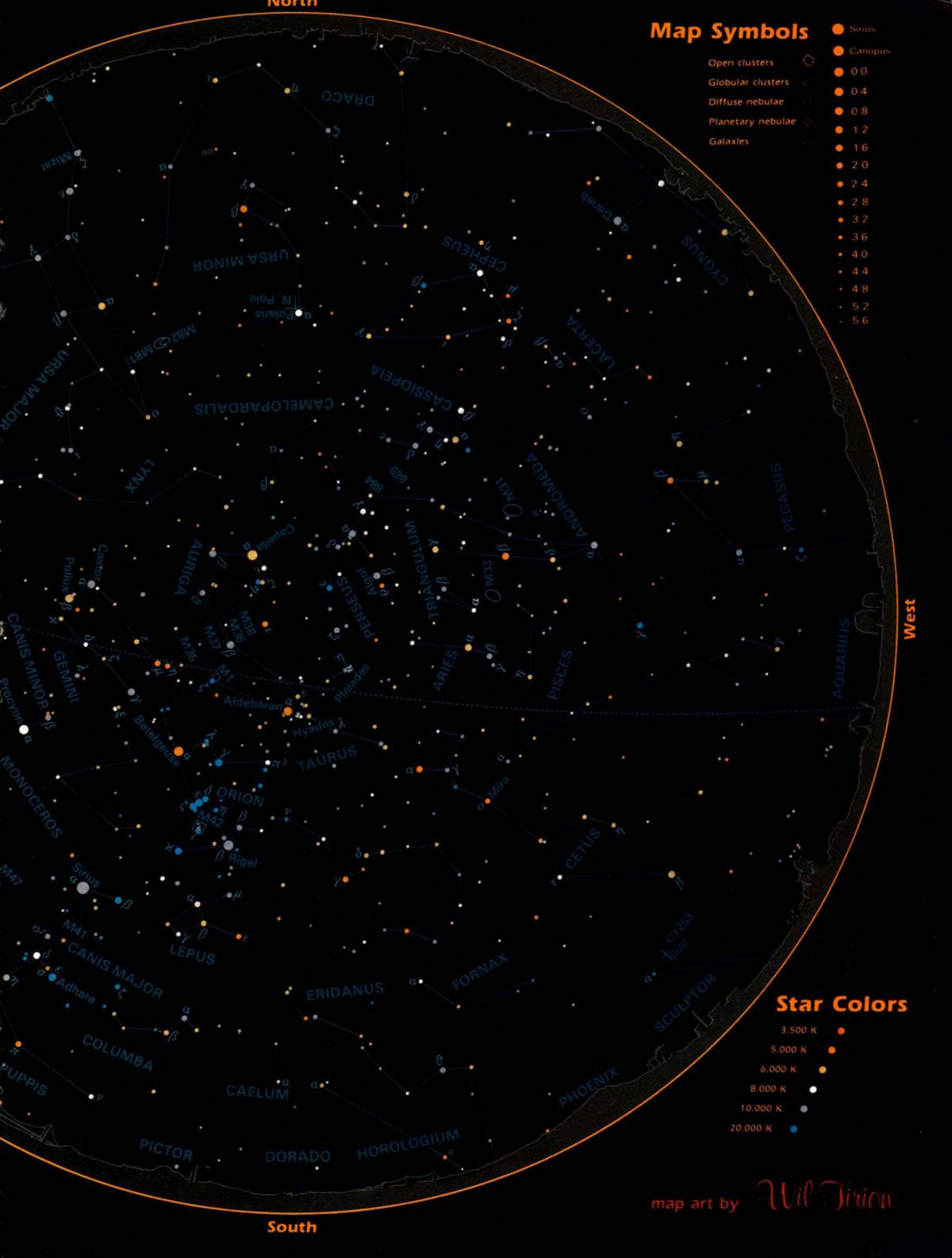
31st Mercury is at superior conjunction.


Looking southwest after sunset, Jan. 12th



The
Star Dome
shows how the
sky looks at:

10:00 p.m. on January 1st
9:00 p.m. on January 15th
8:00 p.m. on January 31st


North
South
West
Map Symbols
Sirius
Canopus
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies
0.0
0.4
0.8
1.2
1.6
2.0
2.4
2.8
3.2
3.6
4.0
4.4
4.8
5.2
5.6
Star Colors
3,500 K
5,000 K
6,000 K
8,000 K
10,000 K
20,000 K
DRACO
Mizar
URSA MINOR
N. Pole
α Polaris
M82
M81
URSA MAJOR
CAMELOPARDALIS
CEPHEUS
CYGNUS
α Deneb
LACERTA
CASSIOPEIA
LYNX
869
884
M31
ANDROMEDA
PEGASUS
Capella
AURIGA
Castor
Pollux
PERSEUS
Algol
TRIANGULUM
M33
ARIES
PISCES
AQUARIUS
M38
M36
M37
M35
M1
Pleiades
Aldebaran
Hyades
TAURUS
CANIS MINOR
GEMINI
Procyon
Betelgeuse
ORION
M42
Rigel
Mira
CETUS
MONOCEROS
M47
Sirius
M41
LEPUS
CANIS MAJOR
Adhara
ERIDANUS
FORNAX
SCULPTOR
253
COLUMBA
PUPPIS
CAELUM
PHOENIX
PICTOR
DORADO
HOROLOGIUM

map art by Wil Tirion

Left top: Orion rises over Yosemite National Park. Photo by Vernon E. Grove Jr., who used Kodachrome 64 and a 16-second exposure at f/1.4 with a 50mm lens. Left bottom: Rick Dyson took this photo of the aurora australis at the South Pole on August 16, 1984, with a 15mm lens, Ektachrome 400, and a 45-second exposure at f/2.8.

belong to a "stellar association" 500 to 2,000 light-years away. An association is a group of stars that shares similar motions through the Galaxy but in a much looser fashion than a star cluster.

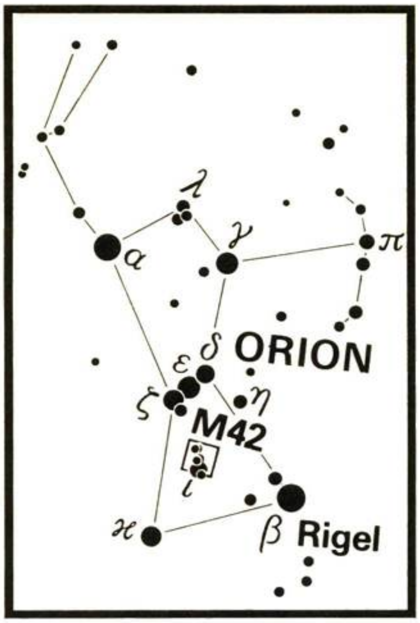
What would remain if we sailed out 2,500 light-years from home? Two of Earth's naked-eye winter stars would remain in this part of the sky — Chi² (χ^2) Orionis and Epsilon (ε) Aurigae. Chi² Ori in Orion's club may be extremely remote — perhaps 4,000 light-years away. Over 3,000 light-years away, Epsilon Aur is a binary system with a red giant star and a very large and mysterious companion object. It is the northernmost of a stellar triangle near Capella called the Kids.

Far behind these two stars would glow the Milky Way. Well to the northwest of Epsilon Aurigae, the brilliant Double Cluster of **Perseus** would still be visible as a naked-eye glow. That pair of clusters lies in the Perseus spiral arm of our Galaxy, farther out from the galactic center than our own arm. The Double Cluster lies about 7,500 light-years from Earth.

Returning to our own backyard sky, we can see another naked-eye glow sinking in the northwest with the Double Cluster. It is M-31, the Great Galaxy in **Andromeda**, over 2,300,000 light-years distant.

To get a different perspective on stellar distance, consider distance as age. The light you see tonight from Sirius and Procyon left these stars when children now in elementary school were born. Stars like Castor and Pollux sent off their light when today's adults were born. The glow of the Pleiades tonight left there in the time of Shakespeare and Queen Elizabeth. The Roman Empire was just drawing to a close when most of the stars we call Orion sent out what we now see of them. The light from the Double Cluster you gaze on this week predates earliest human history.

And M-31? When this galaxy cast its glow, the dominant hominid life form was australopithecine — two million years before the evolution of anything close to modern man.



Skylore

The Hyades star cluster along with the much closer bright star Aldebaran form one of the most prominent asterisms in the heavens. Like the Pleiades, these stars were associated by the ancient Greeks with a number of nymphs. Unlike the Pleiades, however, there is some controversy over the nymph's names, and perhaps as a result of this the individual stars in the cluster have never attracted names to themselves.

According to one account, the Hyades were the daughters of Atlas and Aethra and therefore half sisters to the Pleiades, whose parents were Atlas and Pleione. The two groups of half sisters were sometimes known collectively as the 14 Atlantides — thus seven Hyads to match seven Pleiads.

Yet several ancient writers counted only three or four Hyads; Thales, Hipparchos, and Ptolemy seem to have counted only two. Thales regarded the two Hyads as Alpha Tauri (Aldebaran) and Epsilon Tauri — the two eyes of the Bull. Hundreds of years later, Hipparchos and Ptolemy recognized Alpha and Gamma Tauri as Hyads. R.H. Allen says that in modern times six Hyades stars were counted, but how he arrives at this figure he does not say.

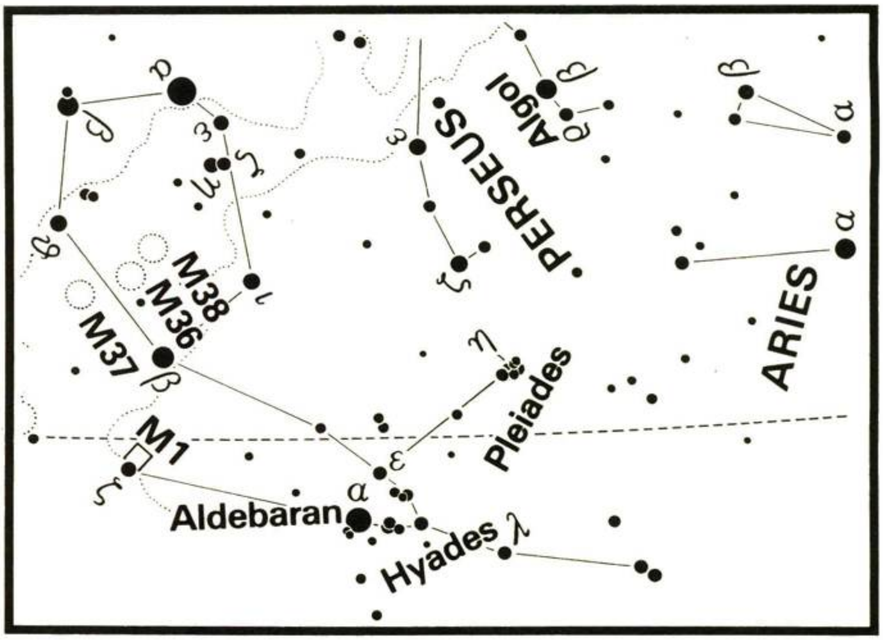
The names of the mythical Hyades date back to the earliest Greek writers, Homer and Hesiod. Hesiod's five names for these stars were Cleia, Phaeo, Cornonis, Eudore, and Phaesyle (or Phaesula). A later list by Pherecydes gives seven names of which two (Eudore and Coronis) are the same as Hesiod's. The other five are Ambrosia, Dione, Aesula or Pedile, Thyene or Thyone, and Polyxo or Phyto.

At least one other very different list of Hyads exists. It comes from a story that they were nurses to the infant god Dionysus. They are called the nymphs of Dodona or Mt. Nysa — the Dodonides or the Nysiades — and their names (according to Robert Graves) were Macris, Nysa, Erato, Bromie, and Bacche.

In this story, Hera, queen of the gods, sought to kill baby Dionysus because he was her husband Zeus' child by the mortal woman Semele. To protect Dionysus, Zeus had Hermes turn the child into a ram and bring him to the nymphs, who cared for him in a secret cave, feeding him honey. Some myths say that these nymphs were later driven into the sea by Dionysus' enemy, Lycurgus, but Zeus saved them by lifting them up to the stars.

The origin and meaning of the name Hyades is curious. In several ancient lands, especially Greece, the cluster was linked to rain because the wet seasons occurred when the cluster set with the Sun in late May and set at sunrise in November. The "wet Hyades" held sway in poetry from Virgil down to Tennyson.

But there is also a story that the sisters had a brother called Hyas, whose death so grieved them that Zeus tried to console them by placing them among the stars. The name Hyades may be a natural derivation from Hyas. The legend goes on to say that the Hyades continued to grieve for Hyas, with their tears producing the rainy seasons. So perhaps Hyas was a later invention derived from rain, too!



There Are A Lot Of Places To Buy

1975 - 1986

Serving Amateur Astronomers
Worldwide Since 1975

America's Largest

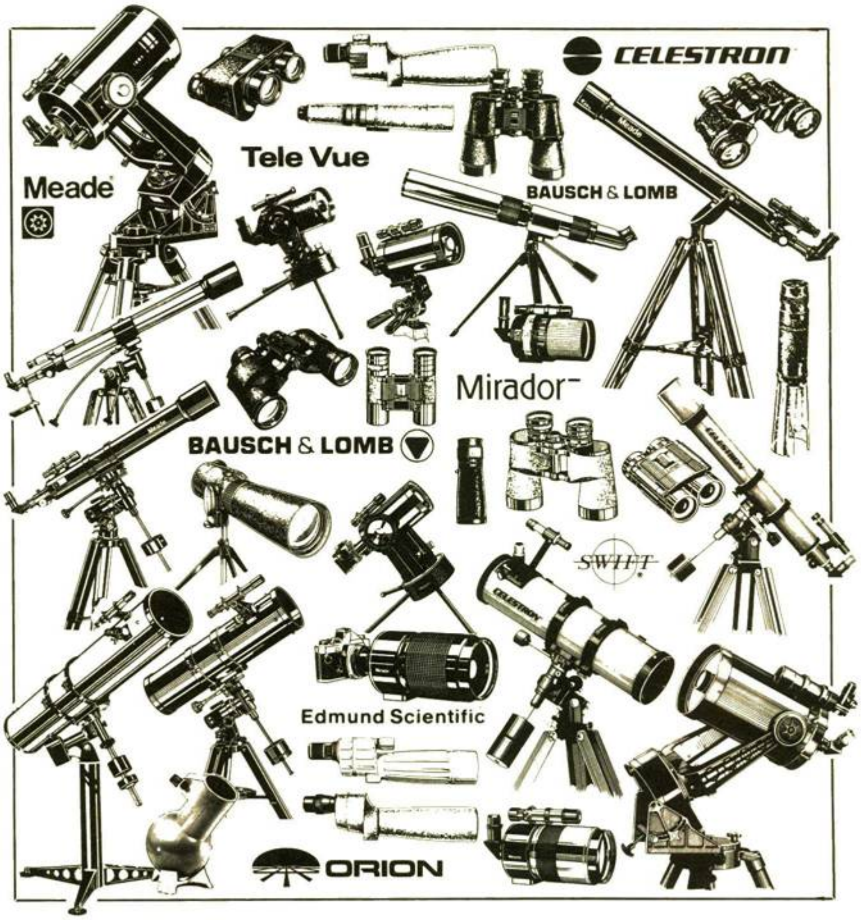
With the return of Halley's Comet just around the corner, it seems like everyone is getting into the telescope business. At Orion, telescopes aren't a sideline. We've specialized in telescopes and accessories for over 10 years. As America's largest full-line telescope dealer, we've earned our reputation for honest, professional service, before, during, and after the sale.

Major Brands

Unlike many smaller companies, Orion is an authorized dealer for all the major brands, and many smaller brands, too. Celestron International. Meade Instruments. Bausch & Lomb. Edmund Scientific. Soligor. Swift. Tasco. Zeiss. TeleVue. Mirador. Bushnell. All listed in our catalog and stocked in our warehouse.

Low Prices

Orion's volume purchasing power means lower costs for us, so we can offer you substantial discounts on telescopes and accessories. You can save hundreds or thousands of dollars on all the popular brands of scopes. And with our money-back guarantee, you can't lose.



Fast Service

Our computerized order processing system gets your order to you fast! And if "comet madness" causes a factory back-order, we'll send you a written confirmation and keep you informed of any delay.

Huge Selection

Orion carries a huge selection of products from all the major manufacturers — over 1400 items in all! More than 100 different telescopes. Over 120 eyepieces. More than 80 different binoculars. And hundreds of accessories, books, camera adapters, electronic controls — everything you need. And our huge computerized inventory system means we'll probably have what you want in stock.

Honest Advice

Let the telescope experts at Orion help you choose the best equipment for your needs. We carry all the major brands, so we can give you an honest evaluation of their differences. We want to save you money, so we're happy to tell you what NOT to buy, if we feel that a product is not right for your needs.

Free Catalog

The Orion Catalog is packed with hundreds of telescopes, binoculars, eyepieces, accessories . . . everything for the amateur astronomer. You'll like our informative product selection guides too. Free Halley's Comet timetable!

Call our toll-free number or write today!

ORION

30 Day Free Home Trial

If you are not completely satisfied with your mail-order purchase from the Orion Catalog, for any reason, just return it in new condition within thirty days after delivery for a full refund.

You be the judge!

A Telescope. Orion Is The Best.

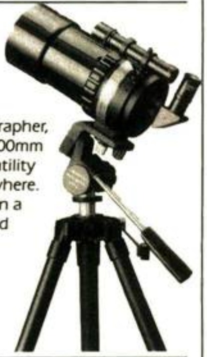
Celestron's Ultimate Schmidt-Cassegrain

The world's most popular modern telescope! Orion's package includes many optional accessories and our Money Back Guarantee. Compact, lightweight fork mount. The Byers 7.54" dia. worm-gear drive system is the best available. Ideal for astro-photographers, the ultimate for observers. Discount priced at Orion! Details in our free catalog.

Celestron's Incredible Newtonian Reflector

This outstanding classical 6" design has been modernized by using high-tech Multi-Coated optics and the great Super Polaris mount. Unique focuser design allows low-profile camera coupling for a brighter, wider field of view. The bright, wide angle f/5 focal ratio is ideal for Comet observing! 8" model also available. Read all about Orion's astrophoto package in our free catalog!

Celestron's Maksutov Spotter Scope



For the astronomer, the photographer, the naturalist. This improved 1000mm system gives you the most versatility and portability you'll find anywhere. Incredible optical performance in a compact high-tech package. And you save a bundle at Orion!

Bausch & Lomb 4" Schmidt-Cassegrain

This compact, versatile, multi-purpose instrument is a telephoto lens, long-range microscope, and astronomical telescope—all in one complete system. The 4" 1200mm F-11 Schmidt-Cassegrain optical system can be used on it's motor-driven astronomical mount or detached to mount on any photographic tripod.

New! Orion Wide-Field Refractor

Our own superb new compact telescope, ideal for astronomical & terrestrial observing and photography. 60mm coated air-spaced objective lens with 1.25" eyepieces, precision 6x30 finder scope. Tabletop tripod, optional camera adapter, erecting prism.

Orion's Own Giant Deep-Sky Binoculars

Our own deep-sky Giant Binoculars are just the thing for viewing Nebulas, Galaxies, and Comets under dark skies. Incredibly wide, bright star fields. Both the 10x70 and 11x80 models feature fully-coated optics, tripod mounting adapter, deluxe case and straps. Center focus design with best 1-piece body construction.

All the Latest Electronic Controls

An explosion of sophisticated electronic controls has arrived. Confused? Whether you want an advanced computer-compatible system or a simple speed controller, Orion can help you match your needs with the best products from all the manufacturers. Our free catalog explains it all.

Eyepieces

No matter what brand or type of telescope you have, Orion has a full range of eyepieces to choose from. More than 120 different types in every size and optical design from all the manufacturers. Celestron. Meade. TeleVue. Bausch & Lomb. Our own Orion Observer's Series. If you need it, we've got it . . . at the right price!

Hundreds of Accessories!

THE NIGHT SKY

Nobody beats Orion's huge selection of accessories! Camera adapters. Carrying Cases. Filters. Tripods. Guide Scopes. You name it. Hundreds and hundreds of the attachments and enhancements you need. Plus a large selection of Orion's own unique products you won't find anywhere else. All at low prices you can afford.

Meade 6" & 8" Professional Series Fast Reflectors

Compact, precise design is ideal for the Comet and a wide range of planetary and deep-sky astronomical observation. Compact, short tube precision Newtonian optical system on sturdy equatorial mounts with optional motor drive systems.

Astroscan 2001

Edmund Scientific's affordable wide-field, go-anywhere telescope gives super bright images PERFECT for Halley's Comet. One of our most popular family telescopes. Discount priced at Orion!

Celestron's German-Equatorial Schmidt-Cassegrain

Celestron's famous 8" optical system on the new, improved, computer-compatible Super Polaris Mount. Built-in polar alignment telescope, adjustable tripod. Low-cost optional single- and dual-axis Quartz Pulse Motor Drives.

Serving Amateur Astronomers Worldwide Since 1975

ORION TELESCOPE CENTER
421 Soquel Avenue, Dept. ST
Santa Cruz, CA 95062

ORION
TELESCOPE CENTER
A Division of Optronic Technologies, Inc.

Order Line & Catalog Requests
800-447-1001
CALIF. 800-443-1001

Tech. Line & Customer Service
408-458-9090

Photography in Astronomy

How to Revive Dull Astrophotos

by
Ben Pate

Probably the most common problem in modern astrophotography is that no matter how hard we try, many backyard astrophotos turn out just plain dull. What can you do about those hard-to-get astrophotos that aren't quite "beautiful" enough? And what if your best attempts at recording Halley's Comet on film — a once-in-a-lifetime opportunity — result in dull, washed-out images?

Fortunately, there are easy, inexpensive, and relatively foolproof methods for dramatically improving astrophotos — techniques that you can either do yourself or get your film processor to do with a little explanation. These photographic tricks of the trade, if properly done, can fix many dull astrophotos and even make them downright impressive.

Fix #1: Make a Darker Print

Color negative film is problematic when used for astrophotography because most prints made from color negatives don't show a dark sky background. Instead, they tend to render the sky in sickly hues of green, blue, or brown. This happens because commercial photofinishers set their automated machines to make prints based on bright, well-exposed shots of people in outdoor settings.

What can you do to change this? It's simple. Take the color negative and the bad print down to your neighborhood photo processor and tell them that you want a darker print, one where the sky appears black or at least a dark, inoffensive tone. It may take some explaining, but once the processors understand what you're actually looking for, they can set the filters and adjust the printmaking machinery to give you a more satisfying print. (Take a copy of ASTRONOMY along and show them what to shoot for.) Of course, if the negative is too underexposed, then a darker print won't help.

Fix #2: Make a Dupe Slide

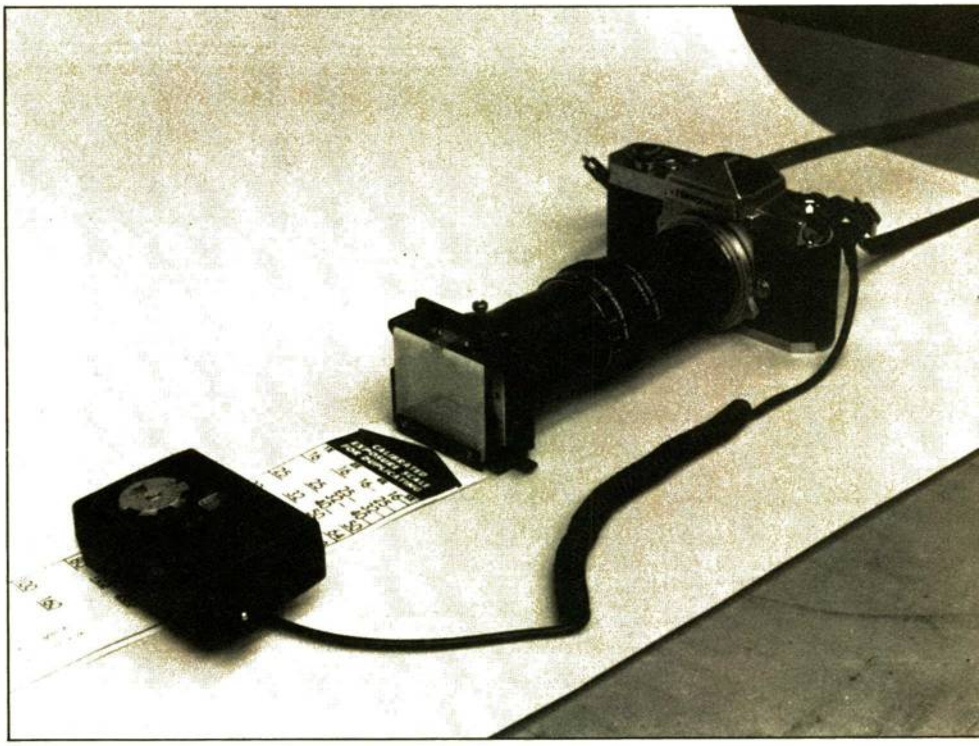
What if you have a color slide showing a nebula so faint that it's barely perceivable? By duplicating the slide onto higher contrast film, you can significantly improve the image. Greater contrast between sky and subject is produced by increasing the exposure to make the subject of the photo — be it be a galaxy or planet — a brighter, crisper, and more impressive image.

There are two ways to go about making duplicate slides. You can take the original slide down to your photo processor, explain exactly what you want, and probably get a pretty good dupe back in a few days. Or you can buy a slide duplicator, a tube-like apparatus that attaches to your 35mm SLR camera and holds a slide several inches away from the film, for about $80. A duplicator allows your camera to make copies of slides quickly and cheaply. It also allows you to control the exposure yourself, adding just enough light to bring up the contrast and details in a slide to your own taste.

(Correcting color balance is considerably trickier than straight copying. But with a set of color-correction (cc) filters you can eliminate those green-slide blues. For detailed information on this rather advanced technique, consult the book section of a large photo store.)

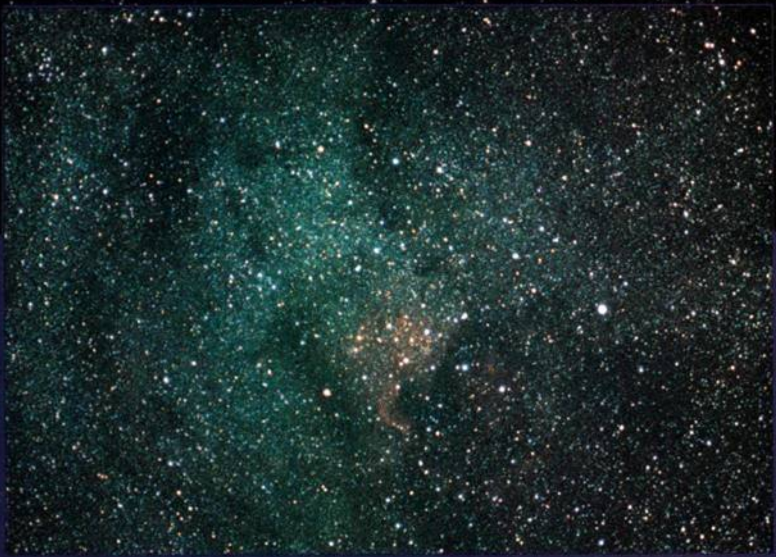
Fix #3: Make an Enlarged Dupe

Duping a slide at 1:1 can yield



Improving Your Image

To create your own home "image processing lab," all you need — aside from a 35mm SLR camera — is a slide duplicator, a reliable flash, and a calibrated scale for determining exposures. Several photo supply companies offer slide duplicating kits (including duplicator, flash, and scale) for under $100. Photo by Robert Burnham.



Darken a Print

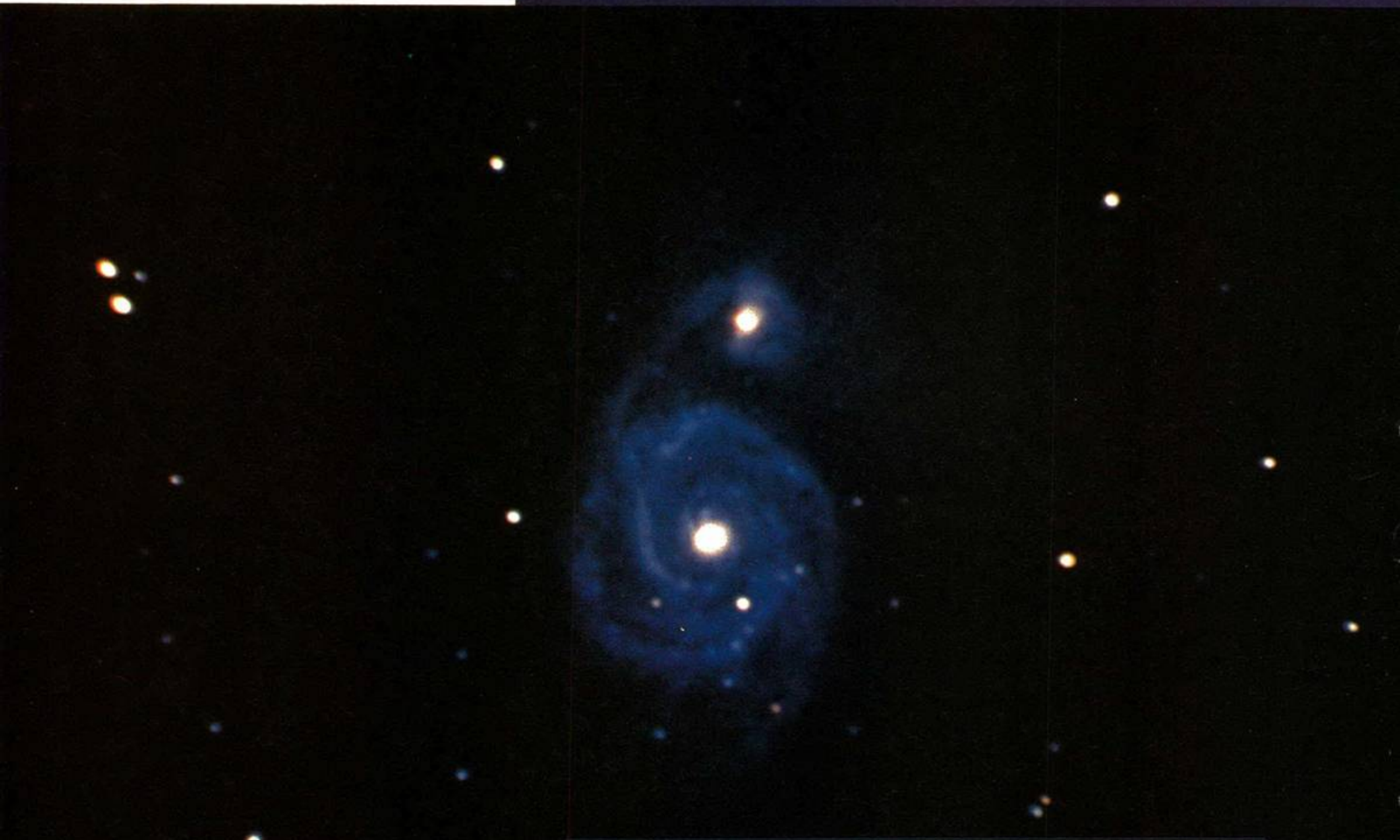
One of the most common problems with color sky photos is an unbalanced, unrealistic — sometimes even grotesque — sky background. You can often eliminate this very simply by taking the print back to your photofinisher and having a darker print made. Photo of the North America and Pelican Nebulae by Ben Pate.

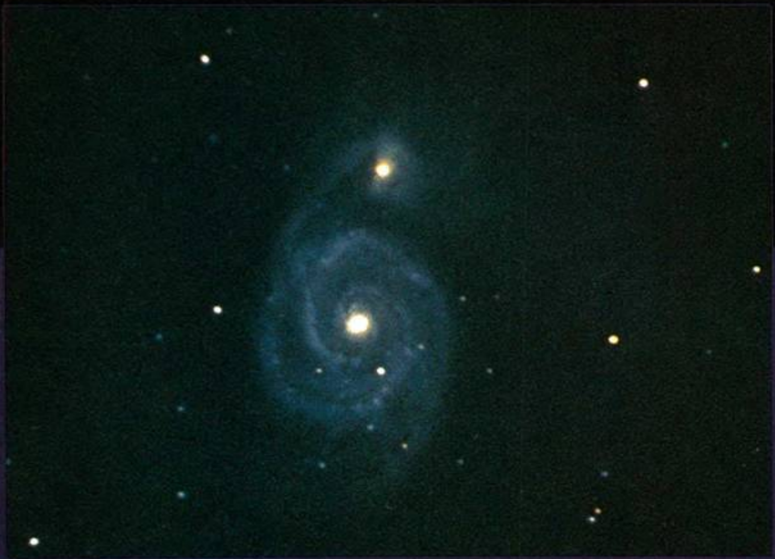
Slide Duping Equipment

What do you need to make your own slide duplicates? A 35mm SLR camera, film, and a slide duplicating setup. A slide duper usually consists of a long tube with a slide mount on one end and an adaptor on the other end that fits onto your camera body. By inserting a slide and (typically) moving a small sliding ring, you can focus and compose a photograph of one of your slides. You make the exposure using a flash unit, which is normally included with the duplicator.

Where can you buy a slide duper? For a start, go down to your local photography store and see what they have. Slide duplicators range in price from $50 to well over $500, though a pretty good one can be purchased for about $100.

Three photographic supply houses selling duplicators by mail are: Spiratone, Inc. (135-06 Northern Blvd., Flushing, NY 11354); Ritz Camera Centers (6711 Ritz Way, Beltsville, MD 20705); and Porter's Camera Store, Inc. (Box 628, Cedar Falls, IA 50613).





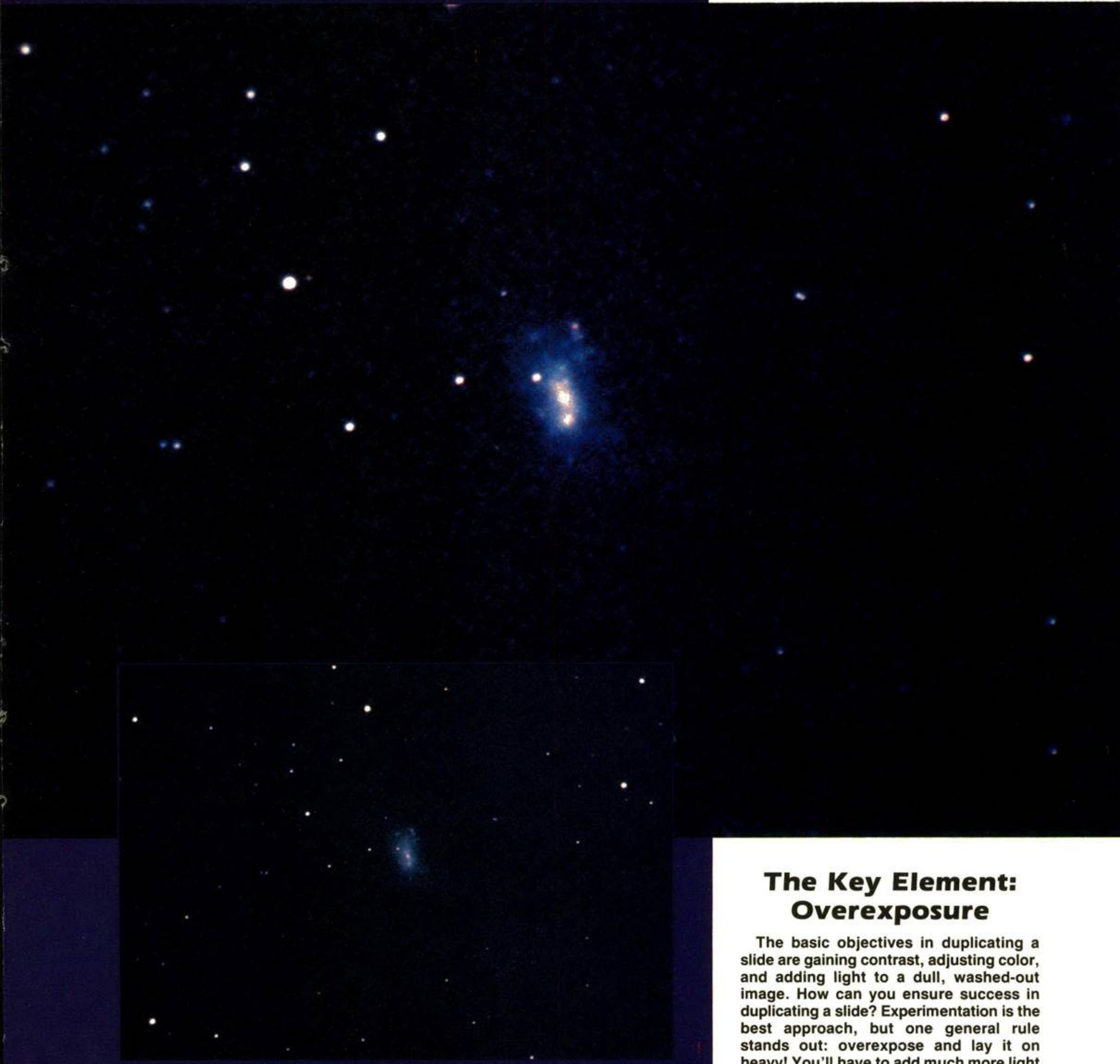
Duplicate a Slide

By mounting a low-contrast slide in a duplicator, you can make your own duplicate slides with improved color, increased contrast, and rich, black sky backgrounds. A slide duplicator costs about $80 and mounts onto a standard 35mm SLR camera. Photo of the Whirlpool Galaxy by David Healy, using a 14-inch f/5.5 SCT, hypersensitized ISO 100 film, and a 60-minute exposure.

increased contrast and color balance, but it won't do much to improve the detail visible in a nebula or galaxy. If you buy your own slide duplicator, it's probably best to invest in a variable magnification model. This allows you to zoom in on a particular section of the original slide, giving an enlarged image with better color and contrast. Enlarging a galaxy, for example, spreads out the image on the film and, within reason, yields a much more impressive and detailed image. Be careful not to *over enlarge* the image or it may go soft and blurry. Commercial copiers give a maximum magnification of about four times.

Fix #4: Make a Print Copy

Another way to save a slide that's too dark is to make a copy print. Put color negative film in your camera, then shoot a series of copies using more and more exposure. The longer exposures will bring out faint colors and detail that's difficult to see in the original. If you have these processed commercially, explain to the processor that you would like a darker background. (Drop by when the shop isn't



Enlarge Your Dupe for Detail

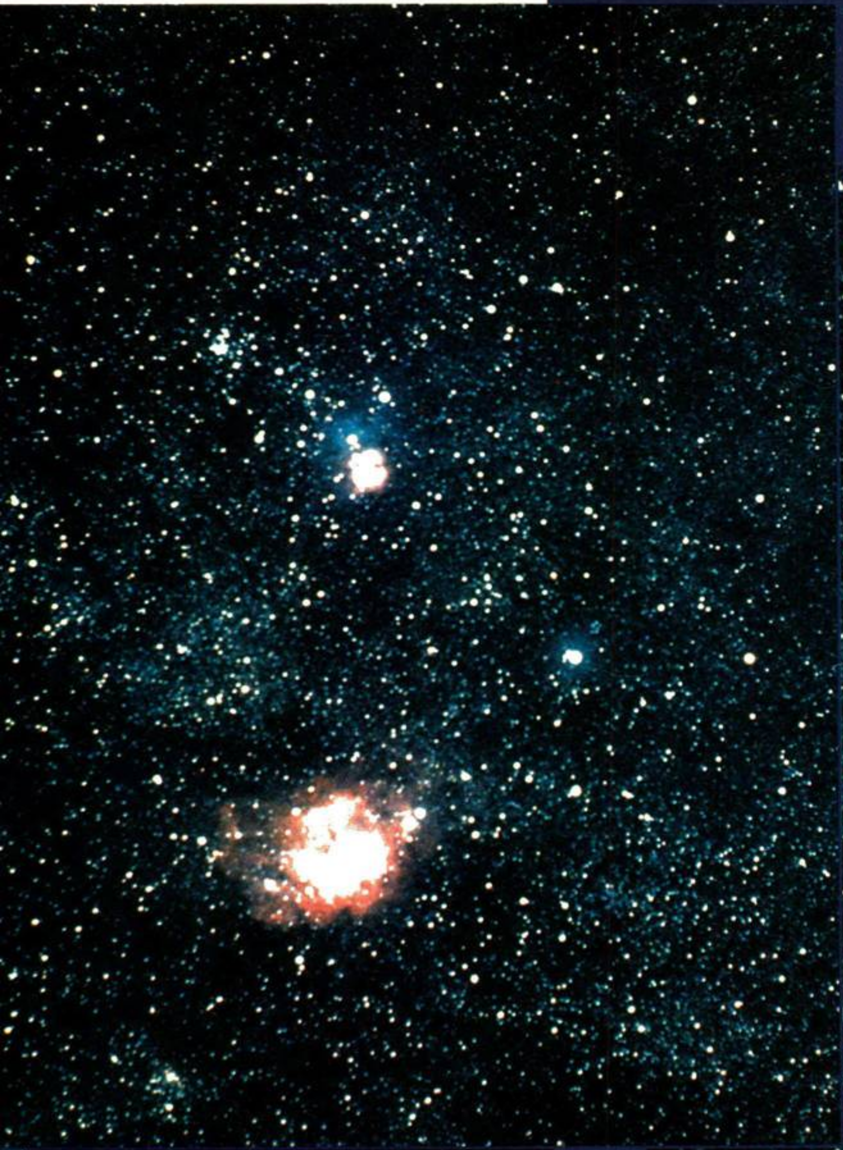
Not only will duplicating a slide improve color, sky background, and contrast, it also allows you to zoom in on a particular section of the original and enhance the image's detail. Photo of galaxy NGC-4449 by Jack Newton; the original was taken with a 16-inch f/5 reflector using 400 ISO film and a 14-minute exposure.

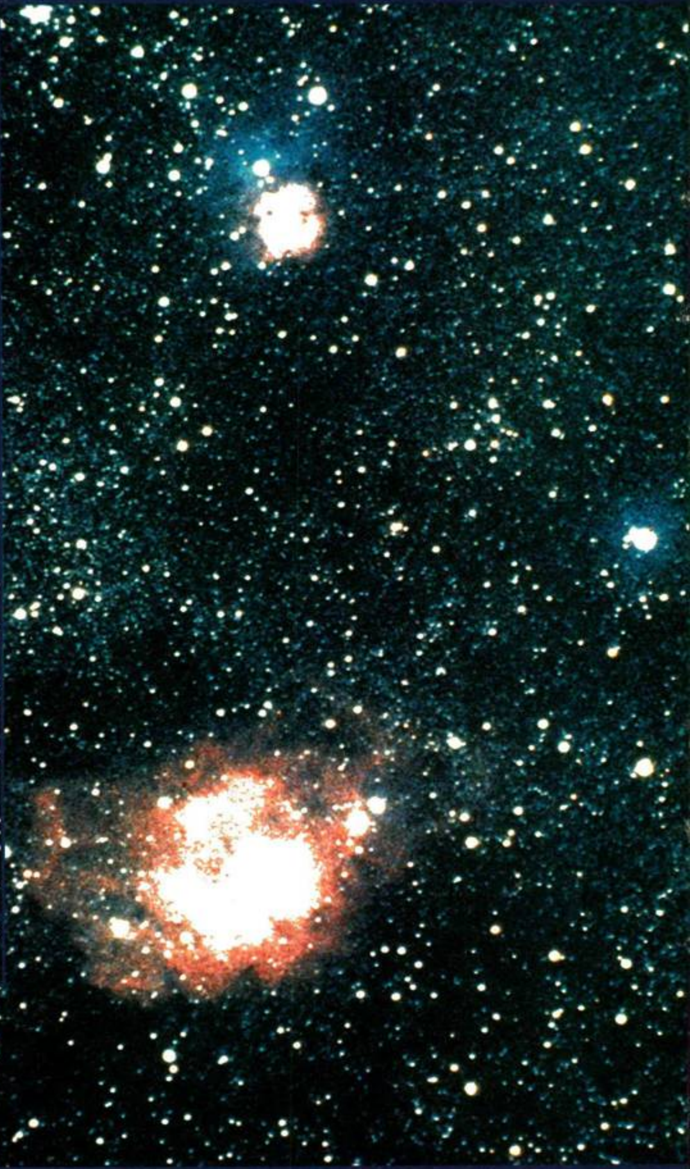
The Key Element: Overexposure

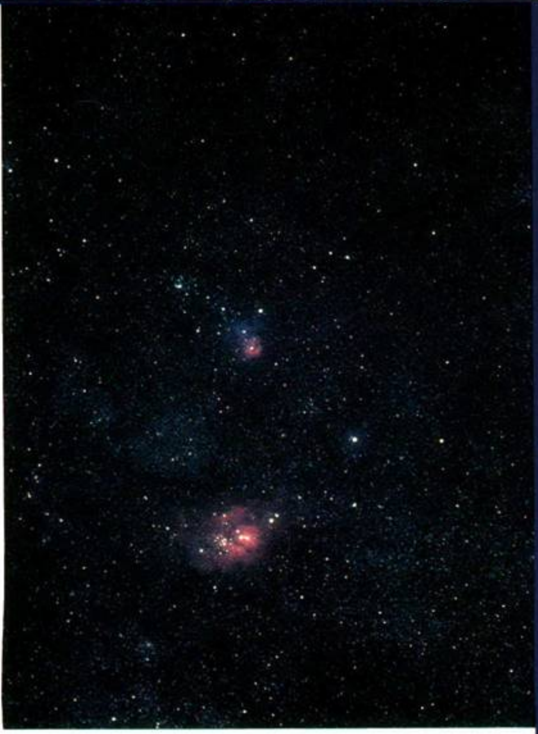
The basic objectives in duplicating a slide are gaining contrast, adjusting color, and adding light to a dull, washed-out image. How can you ensure success in duplicating a slide? Experimentation is the best approach, but one general rule stands out: overexpose and lay it on heavy! You'll have to add much more light than you might think is required.

Start experimenting with a dingy slide by setting up your duper, loading it with fast film, checking that the flash unit works, and figuring out the camera exposure and flash distance. Have enough film on hand so that you can bracket exposures widely. Shoot a +1 stop, +2 stop, +4 stop, and +8 stop exposure of the original. If you make this many exposures, one is almost certain to turn out well. You'll soon get a feel for how much to overexpose different types of poor originals.

Remember: the key is overexposure!

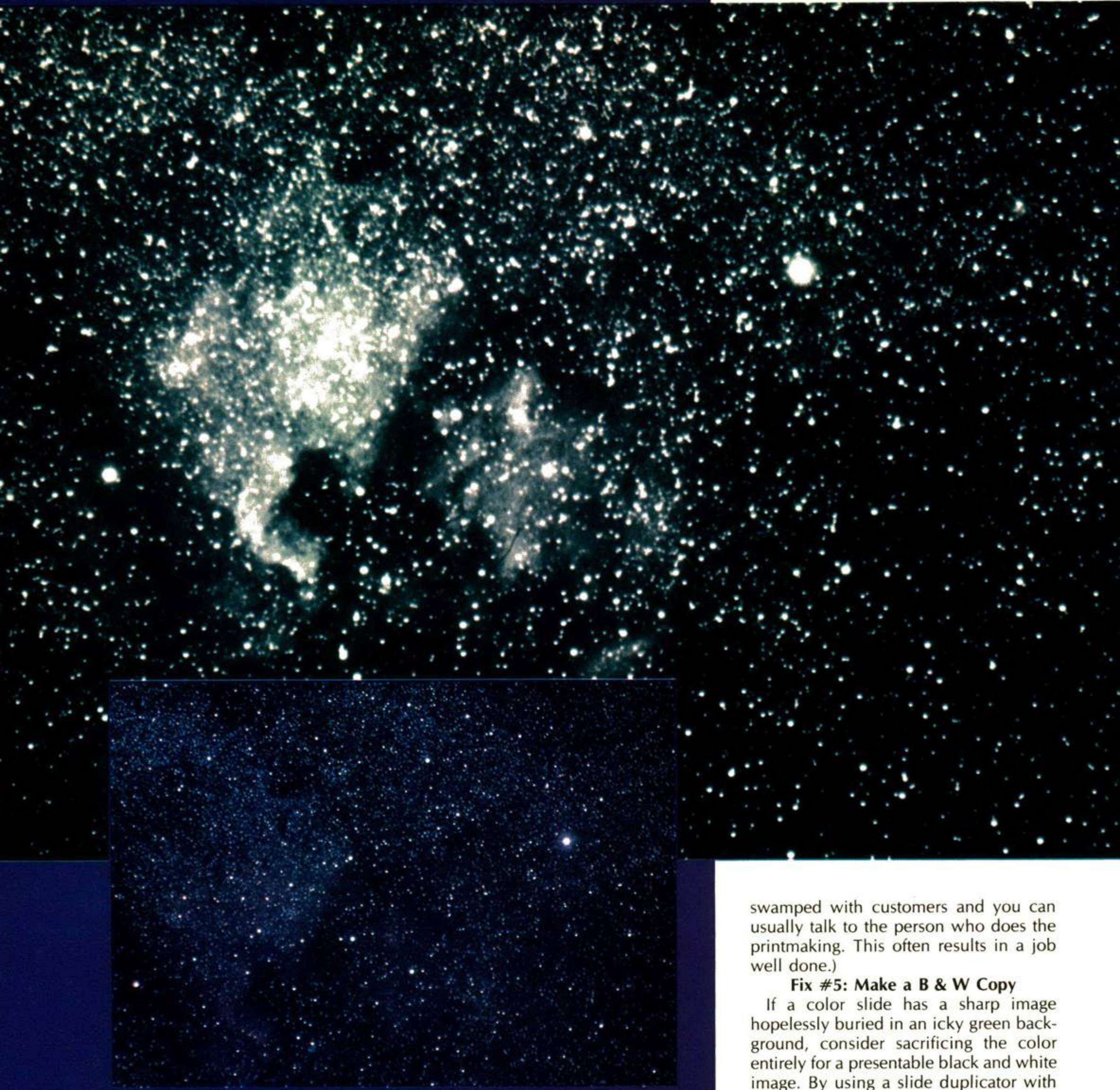






Contrast by Printmaking

What should you do with a low-contrast color slide that you've invested a great deal of time and energy in only to have it turn out short of spectacular? One route is to copy the slide with color *print* film. The final prints should have more contrast and darker backgrounds. You can also enlarge from the print to create an image with much more "punch." Photo of the Lagoon and Trifid Nebulae by Bill Iburg (8-inch f/1.5 Schmidt camera, ISO 400 film, 6-minute exposure).



Weak Color into Good B&W

Due to short exposures or poor processing, colors in otherwise beautiful astronomical shots often appear washed-out or ugly. By copying dull color slides onto high-contrast black and white film, you can turn a weak slide into a zingy black and white image. This photo was copied using a deep red filter for added contrast. Image of the North America Nebula by John Gleason (5-inch f/1.65 Schmidt Camera, 200 ISO film, 20-minute exposure).

swamped with customers and you can usually talk to the person who does the printmaking. This often results in a job well done.)

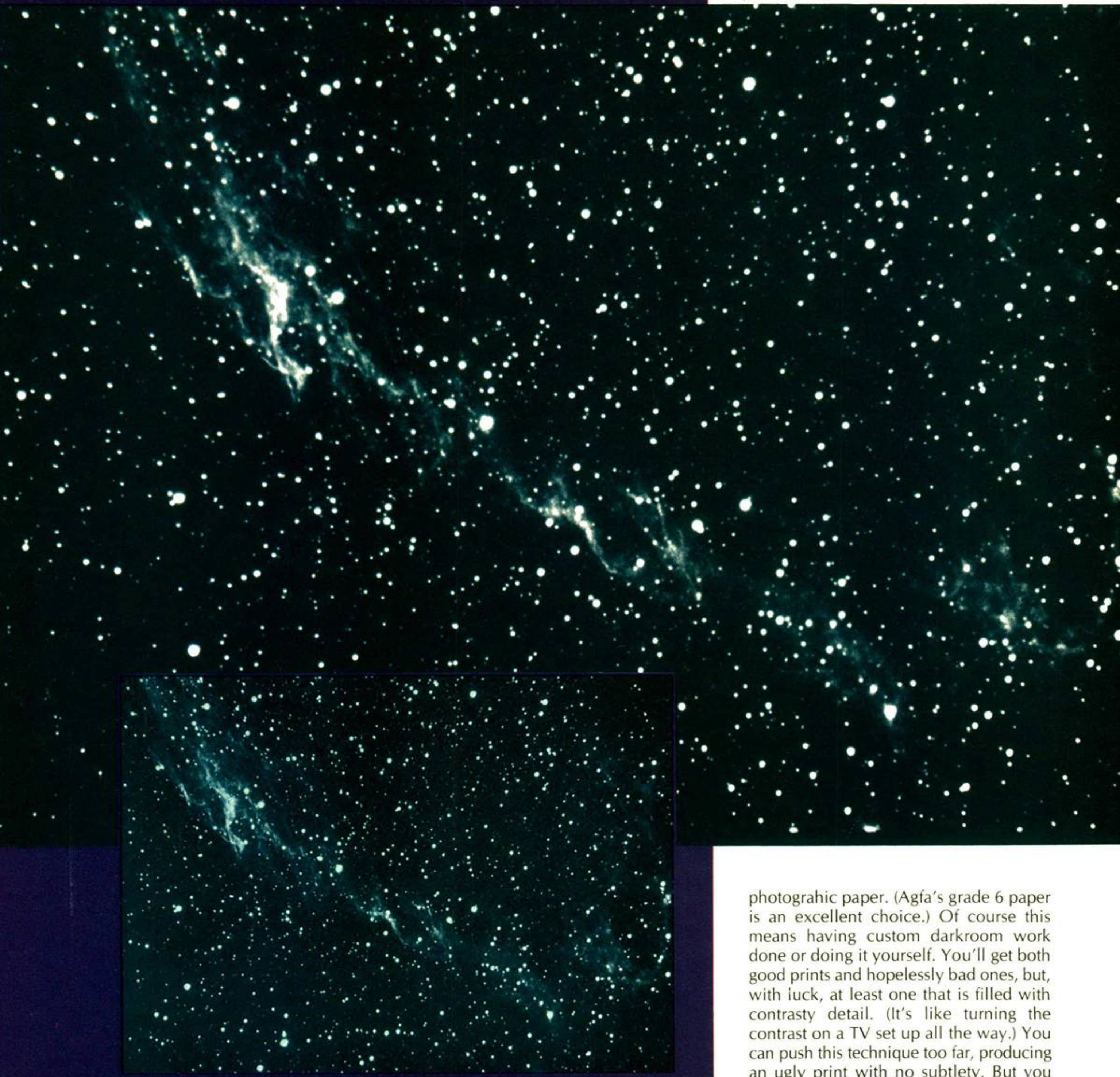
Fix #5: Make a B & W Copy

If a color slide has a sharp image hopelessly buried in an icky green background, consider sacrificing the color entirely for a presentable black and white image. By using a slide duplicator with black and white film, preferably Tri-X or Tech Pan, you can copy a garish color slide onto a black and white internegative, then have the negative printed onto standard black and white paper.

If the feature you want is predominantly red, say a reddish emission nebula, use a red filter to make the nebula brighter and the blue or green background darker. For a bluish galaxy, use a blue filter. This can convert a weak or ugly color image of a faint object into a stunning, high-contrast, black and white picture.

Fix #6: Make a High-Contrast Print

With a black and white copy negative, you can pull out the very faintest details by printing the negative on high-contrast



High-Contrast Copying

A normal black and white print often doesn't bring out all of a negative's subtle details. But by making a high-contrast print using grade 6 enlarging paper, you can pull out delicate nebulosities lost in a normal print. Copying with a red filter helped accentuate faint nebular wisps. Photo of the Veil Nebula by Jack Newton (16-inch f/5 reflector, 18-minute exposure).

photograhic paper. (Agfa's grade 6 paper is an excellent choice.) Of course this means having custom darkroom work done or doing it yourself. You'll get both good prints and hopelessly bad ones, but, with luck, at least one that is filled with contrasty detail. (It's like turning the contrast on a TV set up all the way.) You can push this technique too far, producing an ugly print with no subtlety. But you may also pull out streamers in a nebula or bands on a planet that would otherwise be invisible.

There's an important, little-known maxim in the field of astrophotography these days: if you take some pictures that don't turn out perfectly, *don't give up*! There are at least six easy ways to improve a weak astronomical image, some of which involve simply taking the slides or prints down to a local photofinisher. Or, with an equipment investment of $80, you can create your own re-photography lab and experiment with exposures and filters to your heart's content. Remember, if you have a print or slide that just doesn't excite you, the game's not over yet!

Build Your Own Telescope

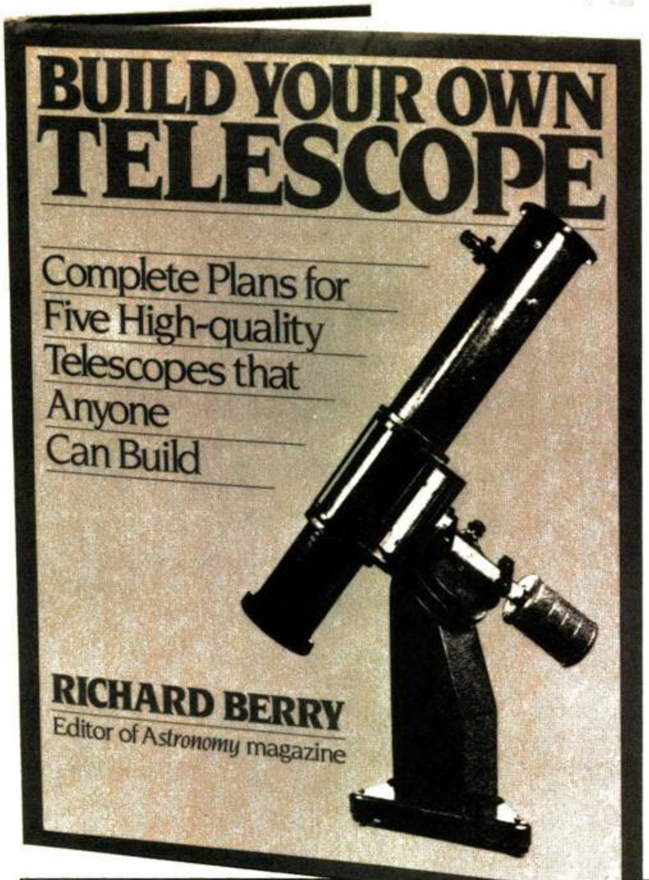
by Richard Berry

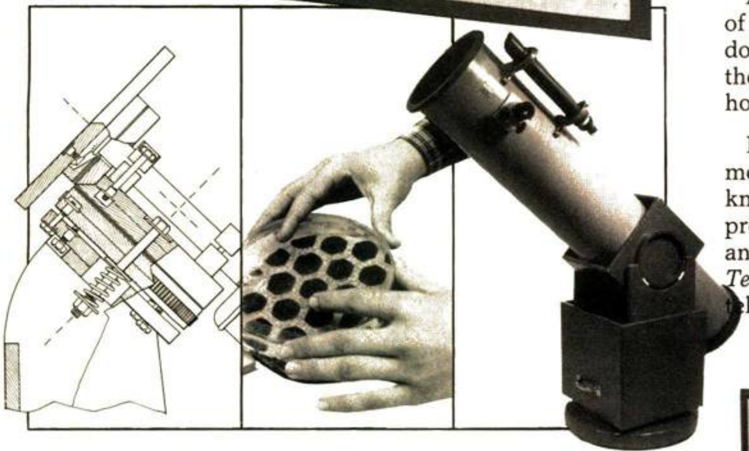
- **Complete plans for five telescopes**
- **Over 200 photos to guide you step-by-step**
- **No special skills needed**
- **Most materials locally available**
- **Optics available from firms that advertise in ASTRONOMY**
- **It's easier than you think!**

How would you like to own a powerful telescope? *Build Your Own Telescope* shows how you can make your own telescope for less time and effort than you thought possible. Choose from five tested designs, then start building. You'll have fun — and learn a lot, too!

Build Your Own Telescope features complete plans and lots of photos. Step-by-step directions show you exactly what to do. Building a telescope takes no special tools, and most of the materials you'll need are available in local hardware and home improvement stores.

Introductory chapters explain how telescopes work, discuss mountings and accessories, and teach you what you need to know about telescope optics. For a challenging do-it-yourself project, there are detailed chapters on grinding, polishing, and testing precision telescope mirrors. *Build Your Own Telescope* includes a bibliography and complete list of telescope parts suppliers.


BUILD YOUR OWN TELESCOPE
Complete Plans for Five High-quality Telescopes that Anyone Can Build
RICHARD BERRY
Editor of Astronomy magazine



Build these telescopes . . .

4″ f/10 Equatorial Reflector
Perfect as a teenager's first telescope or a parent/child project for younger children.

6″ f/8 Dobsonian Reflector
This scope is powerful enough to satisfy an adult and rugged enough to stand up to a troop of Cub Scouts!

6″ f/8 Equatorial Reflector
A classic design for the amateur astronomer or craftsman who wants an elegant telescope and great performance.

10″ f/6 Newtonian
A powerful telescope for the serious amateur.

6″ f/15 Refractor
This large refractor outperforms commercial telescopes of considerably larger aperture.

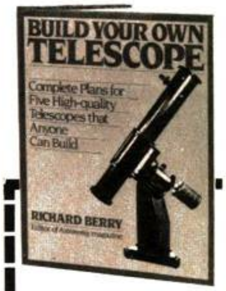
For less than one-third the price of a quality eyepiece, you can buy the book that shows you how to build your own telescope!

Hint: *Build Your Own Telescope* is the ideal gift for that budding young scientist in the family!

Order now!

$24.95

240 pages, hardcover, 8½″x11″



☐ Yes, send me *Build Your Own Telescope*! Enclosed is my payment of $24.95.

☐ Please send me _______ copies of *Build Your Own Telescope*. Enclosed is my payment of $______.

Name ____________________

Address ____________________

City __________ State ______ Zip ______

Send this coupon or a copy to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202, or use the handy ASTRONOMY order form bound into this magazine.

NEW ZEALAND

HALLEY'S WATCH

HURRY!

The Comet is closer than you think. . .

YES, we do have some space still available but don't dally if you want to see Comet Halley!

You choose:

Fully escorted	*14 day*
Campervan	*14 day*
Fly/Drive	*from 7 days*

Prices from $1275 - Air & Land inclusive!

All programs worked in close association with N.Z. Astronomical Societies to bring you special viewing sites & lectures whilst sightseeing by day and skyseeing by night.

Rainbow Adventure Holidays

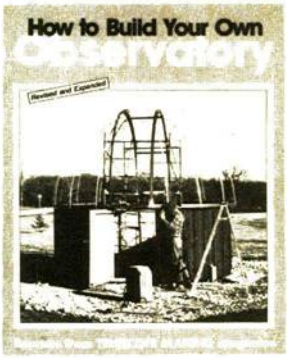
818-702-0111

U.S. 800-722-2288 CA 800-227-5317

Revised and Expanded

How To Build Your Own Observatory

Reprints from TELESCOPE MAKING Magazine



To enjoy the hobby of astronomy to its fullest, you really need an observatory. Our booklet, updated, revised, and expanded, now contains ideas that will help you build 13 great backyard observatories — from a simple shelter from streetlights to a gleaming garage-top dome — even a wooden geodesic observatory that you CAN take with you, if you ever move. Each article, reprinted from past issues of **TELESCOPE MAKING**, includes clearly-written, easy-to-follow instructions, diagrams, and plenty of photos. If you've been dreaming of making your observing sessions more comfortable, now's the time to think about building an observatory. 64 pages, paperback.

ONLY
$5.95

To order, use the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

THIS IS YOUR *BEST* TELESCOPE BUY!

CELESTRON'S *NEW* SUPER POLARIS C8

SUPER POLARIS C8
(Shown with optional 8x50 finder)

LIST: $1750

$929

ASK ABOUT FREE SHIPPING

Celestron's world-famous, time-tested C8 Schmidt-cassegrain telescope on a **newly designed** equatorial mount and tripod, loaded with convenience and operating features! Options include **computer control!**

TELESCOPE FEATURES: 8″ aperture • 2000mm focal length • f/10 focal ratio • Celestron's world-famous, hand-corrected, diffraction-limited, laser-tested, individually-certified optics • Widefield 6x30 finder • 26mm (77x) 1¼″ barrel plossl eyepiece • High-brightness mirror-type star diagonal • 1¼″ visual back • High-tech black finish • Lockable foam-lined carrying case • Dust caps • Starwatch by Ben Mayer • Subscription to *Deep Sky* • Accepts all standard Celestron accessories.

SUPER POLARIS EQUATORIAL MOUNT FEATURES: Built-in, illuminated-reticle polar-alignment scope • Micrometer latitude adjustment (0-90°!) with latitude scale • Micrometer azimuth adjustment • Bubble level • Full 360° worm-drive "slow-motion" controls (with anti-backlash adjustments) and setting circles on both axes (pulse-motor drives optional) • Vernier shaft-locks on both axes • Tube-mount for C8 tube assembly • Sliding-type counterweights • Quick-disconnect counterweight shaft for easy transport • High-damping, adjustable wood tripod • Built-in accessory tray • High-tech black finish. **$929**

LIFETIME LIMITED WARRANTY! LIST: $1750 .... QUANTITY IS LIMITED

TELESCOPE OPTIONS (These are difficult, time-consuming and expensive to retrofit, and thus should be ordered initially if desired):

- "Special Coating"—High-transmission, anti-reflection coating on corrector plate-increases light through-put approximately 10%, and improves contrast and color saturation! **ADD: $175.**
- "Starbright Coating" (includes special coating)—High-reflection, enhanced-silver coating on both mirrors—in combination with special coating, increases light through-put approximately 20% (close to theoretical max.) **ADD: $350.**

SUPER POLARIS MOUNT OPTIONS: (These may be easily retrofitted) • Single-axis D.C. Pulse-motor drive/corrector • Dual axis D.C. pulse-motor drive/corrector • **Sky Sensor** dual-axis computerized control system • Call for price and availability of these drive options.

THESE PRICES EFFECTIVE JANUARY 2, 1986

CALIFORNIA TELESCOPE COMPANY

P.O. Box 1338, Burbank, California 91507
Send *Business-size* SASE for discount price list
U.S. sales only—Calif. residents add sales taxes

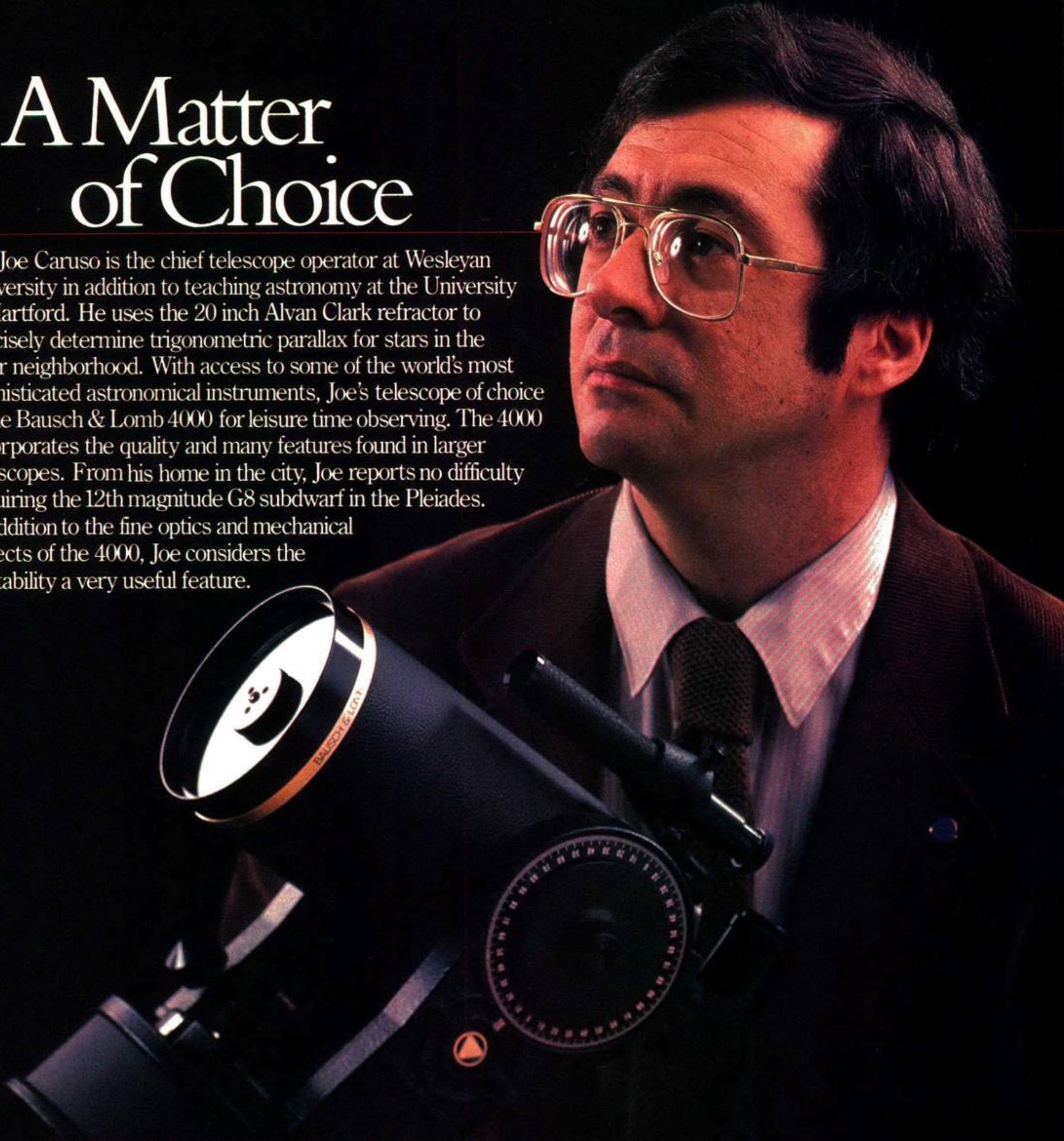
MasterCard VISA

Orders only, 10-4 Pac. Time, Mon-Fri:
(818) 505-8424

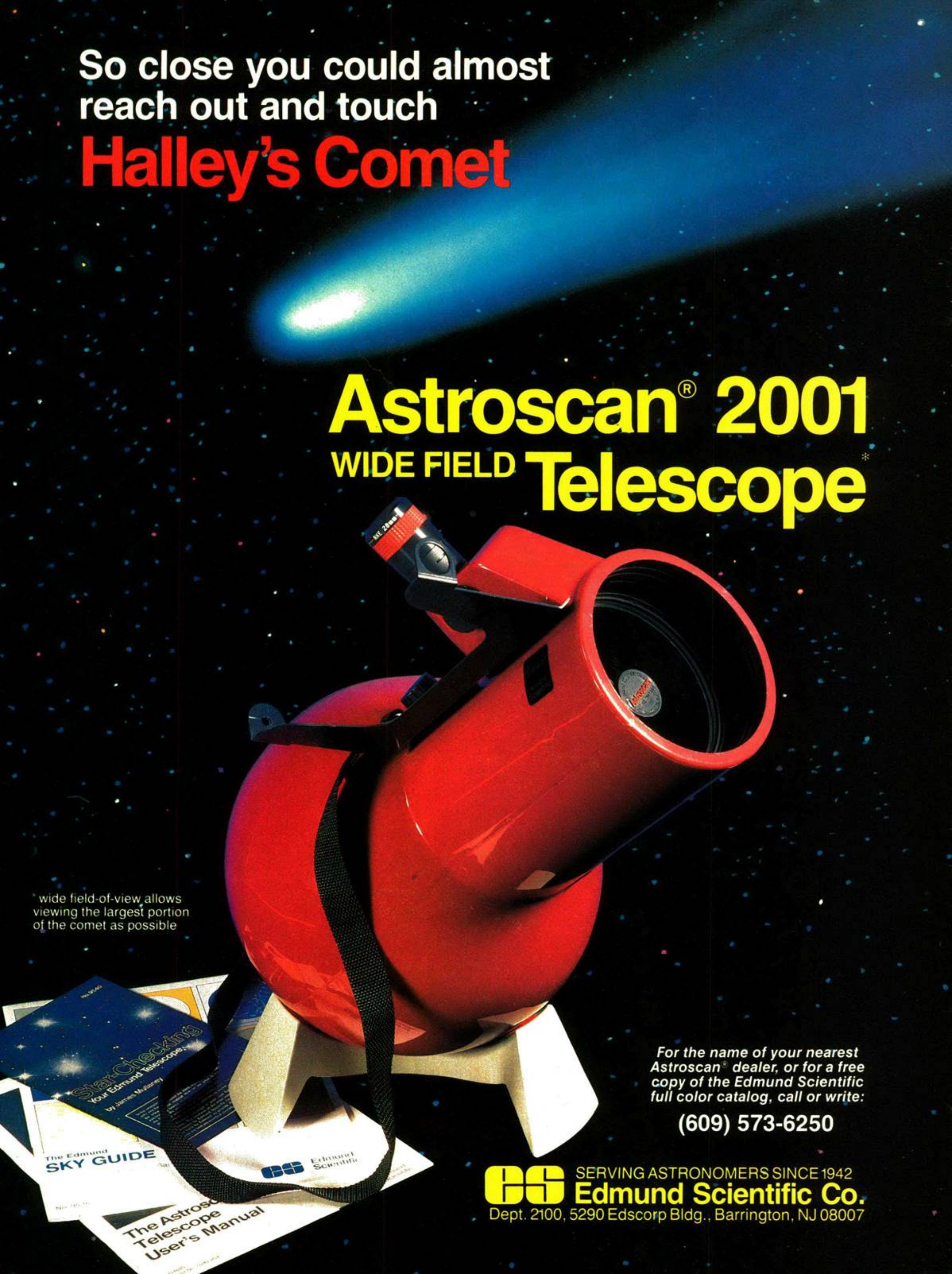
CELESTRON: ENTERING A NEW ERA

A Matter of Choice

Joe Caruso is the chief telescope operator at Wesleyan University in addition to teaching astronomy at the University of Hartford. He uses the 20 inch Alvan Clark refractor to precisely determine trigonometric parallax for stars in the solar neighborhood. With access to some of the world's most sophisticated astronomical instruments, Joe's telescope of choice is the Bausch & Lomb 4000 for leisure time observing. The 4000 incorporates the quality and many features found in larger telescopes. From his home in the city, Joe reports no difficulty acquiring the 12th magnitude G8 subdwarf in the Pleiades. In addition to the fine optics and mechanical aspects of the 4000, Joe considers the portability a very useful feature.



BAUSCH & LOMB
ASTRONOMICAL DIVISION
135 Prestige Park Circle, East Hartford, CT. 06108


So close you could almost reach out and touch
Halley's Comet
Astroscan® 2001
WIDE FIELD Telescope*
Star-Checking Your Edmund Telescope by James Mullaney
The Edmund SKY GUIDE
Edmund Scientific
The Astroscan Telescope User's Manual

* wide field-of-view allows viewing the largest portion of the comet as possible

For the name of your nearest Astroscan® dealer, or for a free copy of the Edmund Scientific full color catalog, call or write:

(609) 573-6250

SERVING ASTRONOMERS SINCE 1942
Edmund Scientific Co.
Dept. 2100, 5290 Edscorp Bldg., Barrington, NJ 08007

Be ready for this once-in-a-lifetime event. Capture the beauty of Halley's Comet, the wonders of the Milky Way, a distant star or the moon's craters.

Designed to take only seconds for almost anyone to set up and begin star gazing. Space Age design eliminates cumbersome mounts. 4¼" wide field Newtonian scope shows the greatest number of stars in one view. Low light design provides bright, crystal clear images and a remarkable clarity of celestial objects. Features a wide 3° field of view. Special high impact red plastic body will withstand the rigors of years of active use. Weighs less than 11 pounds. 16X magnification allows you to use scope to see land images by day (optional image erector corrects a telescope's usual upside down image). Only 17 inches long, yet outperforms telescopes several times its size. Your Astroscan is ready to go when you are. Includes "Star Checking Your Edmund Telescope" and "The Edmund Sky Guide."

Astroscan® 2001. Includes telescope, base, 28mm RKE eyepiece, finder sight, dust cap, and instructional aids. **A2001 $299.00**

Astroscan® 2001 (with image erector). Allows you to view objects right side up. Also permits you to see land objects correctly. **A2008 $349.00**

Specifications

Primary Mirror: 4⅛" (105mm); clear aperture f/4.2; 17½" (445mm) f.l. parabolic; Pyrex aluminized and overcoated; figured to ⅛ wave; factory precollimated and fixed.
Secondary Mirror: Elliptical 1.5" minor axis; ⅛ wave flat; aluminized and overcoated. Diagonal support mounted directly to an anti-reflection coated optical window.
Eyepiece: 28mm e.f.l. RKE; 45 degree field; standard 1¼" O.D. barrel.
Magnification: 16X with 28mm RKE; 76X with optional eyepieces and Barlow.
Field of View: 3.0 degrees at 16X.
Focuser: Positive-grip rubber roller type. Focus 25 feet to infinity.
Weight: Scope weighs 10.75 lbs. Base is two lbs.
Body: Special high-impact red plastic.

Accessories

Sun Screen: Allows viewer to see sun spots safely. **A31,777 $29.95**
Tripod Bracket: Adapts Astroscan® to a camera tripod. Aluminum. **A72,314 $29.95**
Rubber Base Mat: Anti-skid protection for use on a car or table. **A83,023 $ 6.95**
Tote Bag: Protects Astroscan® while traveling. **A42,698 $24.95**

Sets up in seconds. Simply set it on a flat surface and you're instantly ready to observe.

Unique telescope design allows you to cradle it comfortably in your arms.

Lightweight, take it anywhere. Comes with detachable carrying strap so you can tote it along while hiking.

• EDMUND • LUMICON • UNITRON •

MEADE • TELEVUE • CELESTRON •

NIKON • BAUSCH & LOMB • SWAROVSKI •

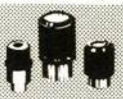
All Major Brands In Stock
with competitive prices and expert advice!

Meade
THE LEADER'S EDGE
- New 2045
- 97D
- New 2080 LX3

Precision Optics By
CELESTRON®
PRECISION OPTICS
- Super C-8 Plus
- C-90 Astro
- Cometrons

Giant Binoculars
20x80 • 30x80

Tele-Vue
Eyepieces



- Naglers
- Wide fields
- Plossls
- Renaissance Telescopes

THE EDMUND ASTROSCAN 2001™
In Stock!

- Complete book & star chart selection
- We **are** experts on Astrophotography
- One of the East Coast's largest dealers
- Expert advice over the phone — call or write Joe, John or George

Complete selection of all photographic and video equipment in stock.

BERGER BROS.
CAMERA EXCHANGE
209 Broadway (Rte 110), Amityville, NY 11701 (516) 264-4160
We Ship UPS in 48 Hours TOLL FREE 950-1088 (tone) 264-4160

TELRAD • PENTAX • FUJINON •

It lights up in the dark!

Rand McNally Presents Mercury—
A World-Class Relief Globe

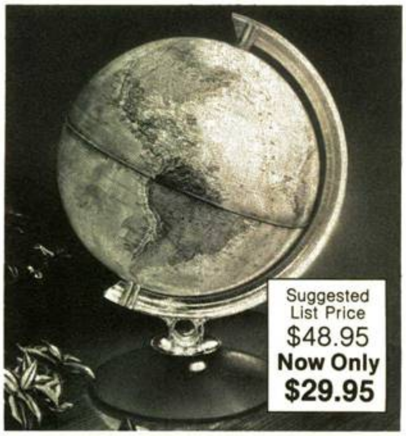
A globe is like an encyclopedia or Bible—no educated home is complete without it. Maps are all very well and good, but only the three-dimensionality of a globe can accurately represent the shape and proportions of our planet.

Now Rand McNally has designed the Mercury Relief Globe, a magnificently detailed, 18"-tall model of the world. And it's available for only $29.95! Never before has such a high-quality globe been sold at such a low price.

An Earthshaking Bargain at Only $29.95

The Mercury offers features you just won't find on a conventional globe. It's made of attractive, durable polystyrene and shows the earth's topography, elevations, vegetation patterns, ocean currents, international date line and more. The globe contains 2,351 place names, from the tallest peaks to the tiniest islands!

As if all that weren't enough, the Mercury GLOWS IN THE DARK, revealing national boundaries and country names printed in contrasting solid colors. And so, the globe can serve as a night light for your child while teaching him about geography at the same time!



Suggested List Price $48.95
Now Only $29.95

The *Free* Globe Handbook Gives You a World of Information

To ensure that you get the full enjoyment out of your Mercury, we're including a full-color handbook that tells how to use the globe and explains earth-space relationships, the planets, and more.

© 1985 Barnes & Noble Bookstores, Inc.

SINCE 1873
Barnes & Noble BY MAIL ONLY
BOOKSTORES
Dept. G183, 126 Fifth Ave., N.Y., N.Y. 10011

1171875. Please send me ____ Mercury illuminated Globe(s) at your special sale price of only $29.95 (plus $3.00 each shipping and insurance). N.Y. and N.J. residents, please add sales tax.

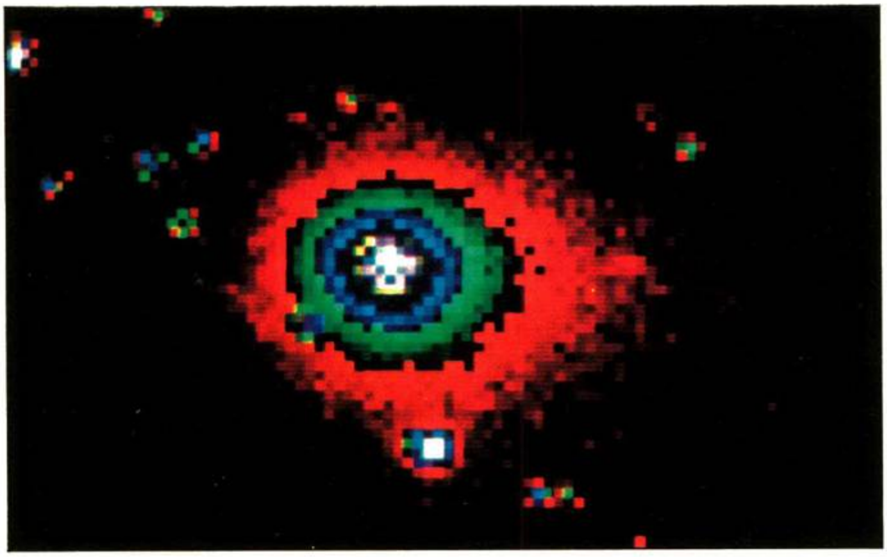
✓ **Check one** ☐ Payment enclosed
☐ MasterCard ☐ AMEX ☐ VISA

Account# ____________ Exp.____
Signature ____________
Offer good only in continental U.S.A.

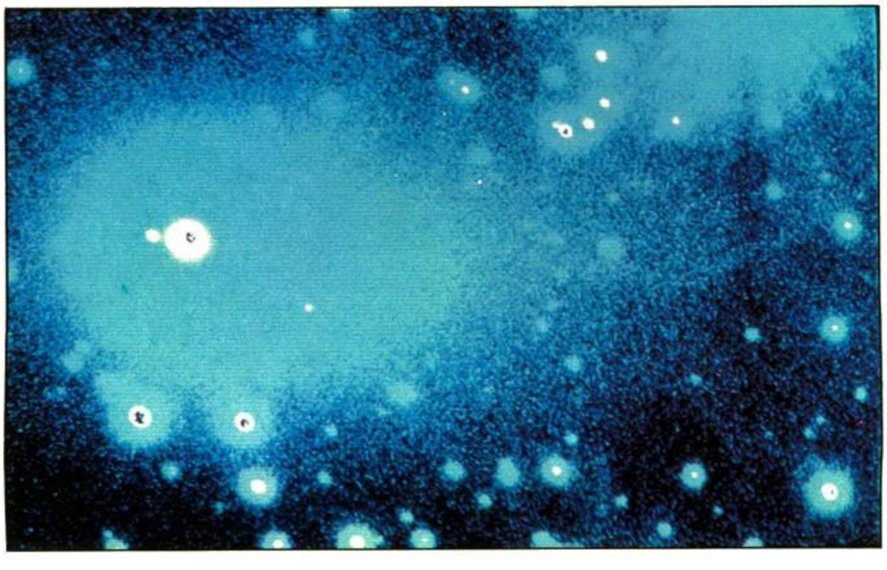
Please allow 3-5 weeks for delivery.
Name ____________
Address ____________
City ____________
State ____________ Zip ____

For Faster Service
Credit Card Customers Call Toll Free
1-800-228-3535
24 Hours-7 Days a week In Nebraska 1-800-642-9606
30 DAY MONEY-BACK GUARANTEE

AstroNews



Above: This false-color photograph of Halley's Comet was made on September 25th by James Gibson of the Jet Propulsion Laboratory. Gibson used Palomar Observatory's 1.5-meter Cassegrain reflector coupled with a red filter, which reveals the comet's dust coma rather than the gaseous coma. Computer enhanced to display increasing levels of brightness (concentric rings of color), the photograph also shows the newly-developing tail as an asymmetrical bulge. Courtesy Palomar Observatory. Below: A CCD image made using Kitt Peak Observatory's 2.1-meter telescope on September 17th clearly shows Comet Halley's tail. Photo by John Gallagher; courtesy National Optical Astronomical Observatories.



Soviets Plan Big

The Soviet publisher Znaniye ("knowledge") recently released a pamphlet called *Stroitel'stvo v Kosmose* ("Construction in Space"), which offers rare insights into the Soviet's thinking on space construction and future plans. The 60-page pamphlet, written by Aleksey Sergeyevich Gvamichava and Vladimir Alekseyevich Koshelev, was translated by the U.S. Department of Commerce's National Technical Information Service.

According to the authors, the construction of space structures in orbit is necessary because "there are a number of urgent tasks in the mastery of space whose solution requires structures which in size considerably exceed the dimensions of the 'holds' of modern booster rockets."

The Soviets expect such structures to include: radar antennae for Earth observations; radio antennae for satellite broadcasts and receipt of data from spacecraft exploring the solar system; large radio and optical telescopes; satellite solar power stations for broadcasting power to Earth; mirrors to reflect solar radiation to Earth; orbital factories; and space "shipyards."

One potential method under consideration by the Soviets for deploying large antennae involves centrifugal force. The.entire structure would rotate, causing it to unfold and then maintain its shape. This design is favorable because it is lightweight, compact, and would enable construction of antennae up to two kilometers in size. But moving parts, potential entanglement during deployment, difficulty of testing on Earth, and control problems must still be solved.

The Soviets are also considering inflatable structures; however, meteoroids are an obvious hazard. Using electrostatic or magnetic deployment, this method is also lightweight and compact for storage during lauch. Flexible solar cells (which will be demonstrated on the Space Telescope) and the construction of space platforms are also being considered.

Soviet designs for girder-building machines appear similar to those designed by NASA.

In the pamphlet, the Moon is described as "the most attractive place for establishing the first scientific production base" because, among other factors, "an insignificant gravity six times less than at the Earth's surface [favors] the construction of relatively massive structures, [and] the constant turning of only one side toward Earth [favors] the maintenance of constant or emergency communication."

The authors believe the first lunar base will be functioning "at the beginning of the next century." Initially, space stations will be launched into lunar orbit, followed by a "lunar living complex" for 10 to 12 people. This early base may be constructed from "the compartments of space vehicles covered with lunar ground to shield personnel against radiation." Power will be supplied by solar power satellites at the lunar libration points.

There is no way to guess how closely such plans — presumably authorized by scientists and engineers rather than their political bosses — actually represent Soviet thinking. However, this pamphlet was published by the Soviet press for a popular audience and therefore had Soviet approval. It is also clear, if Western civilian and military reports can be believed, that the Soviets are indeed developing the launch capacity for ambitious undertakings such as these. What the new Soviet leadership plans for this technology remains to be seen, but continued efforts at space habitation suggest that Russian space ambitions continue unabated. *Donald F. Robertson*.

Solar Research Satellite Destroyed in Missile Test

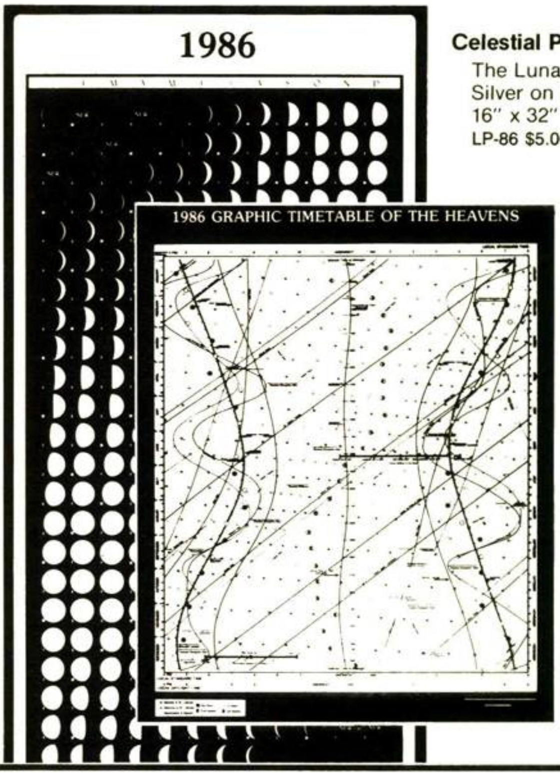
The first casualty of the United States' antisatellite program was an active satellite conducting solar corona research at the time it was shot down. Air Force satellite P78-1, the target of the mock attack, was destroyed by an experimental missile on September 13, 1985, in what Secretary of Defense Caspar Weinberger called "a great step forward" for the antisatellite program.

P78-1 was chosen as the target for the test after a special Air Force target vehicle developed electronic problems earlier in the year. According to the Air Force, P78-1 had "satisfied all of its programmatic basic research requirements." It had "outlived its useful life," Air Force General Bernard Randolph said on the day of the test.

The satellite was carrying an experiment called Solwind, which had been photographing the Sun's corona since 1979. The Naval Research Laboratory in Washington, D.C., has produced noteworthy research from this data, according to physicists interviewed by *Science*

SKY GRAPHICS

from **Scientia, Inc.**



Celestial Products Moon Calendar

The Lunar Phase for Each Day
Silver on Blue
16" x 32" Shipped Rolled
LP-86 $5.00 plus $1.50 shipping

Graphic Timetable of the Heavens

- **Over 10,000 Planetary and Lunar Events Charted**
- **Rising, Transit & Setting Times**
- **Eclipses, Conjunctions & Oppositions**
- **Phases of the Moon & Apogee & Perigee**
- **Six Colors with Blue-Black Border**
- **16" x 20" Shipped Rolled**
- **TT-86 $5.00 plus $1.50 shipping**

Order both for $12.00 including shipping

Send check to:

Scientia, Inc.
1815 Landrake Road
Baltimore, MD 21204
Phone (301) 828-5494

OWN A PIECE OF THE HEAVENS!

Comets and Moons from Stellar Vision...

Non-Toxic . Non-Radioactive

These art objects are handsomely framed to hang anywhere in your home. When you turn out the lights they shine and give you a pleasant night sky illusion no matter what the weather is like outside.

Relaxingly Romantic.
The Perfect Gift.
Order today for years of enjoyment.

Stellar Vision incorporated

"Satisfaction Guaranteed"
or your money back

Mail to:
Stellar Vision Corp.
P.O. Box 30474
Portland, OR 97230

Please send me the following luminous art objects:

Frame Color Check One **Price** **Quantity**

☐ Gold ☐ Silver **$14.95** x # \_\_\_\_ =**$**______
☐ Gold ☐ Silver **$14.95** x # \_\_\_\_ =**$**______
☐ Gold ☐ Silver **$14.95** x # \_\_\_\_ =**$**______
☐ Gold ☐ Silver **$14.95** x # \_\_\_\_ =**$**______
☐ Gold ☐ Silver **$14.95** x # \_\_\_\_ =**$**______
☐ Gold ☐ Silver **$24.95** x # \_\_\_\_ =**$**______

Appropriate sales tax if any ______
Add 1.75 each shipping and handling = ______
Total enclosed $ ______

NAME __________
ADDRESS __________
CITY __________
STATE ______ ZIP ______

☐ Mastercard ☐ VISA
☐ Money Order ☐ Check
Card No. __________
Expiration Date __________
Name __________

Thank you for your order.

CELESTRON®
PRECISION OPTICS

TELESCOPES
&
ACCESSORIES

NORTHERN NEW JERSEY'S
LARGEST SELECTION

DOVER PHOTO SUPPLY
25 E. BLACKWELL ST.
DOVER, N.J. 07801
201-366-0994

★ COMETWATCH ★
OBSERVE & UNDERSTAND COMETS
SOFTWARE FOR YOUR
APPLE II+/IIe/IIc   COMMODORE 64/128   IBM PC/XT/JR

BE READY FOR HALLEY'S COMET!

COMETWATCH gives you three programs to calculate comet data, plus background on the physics of comets, how to observe them and detailed information on Halley's Comet and its return to the sun in 1985/86.

- Calculation and on screen plot of any comet orbit with sun and orbits of Mars, Jupiter, Saturn and Uranus for reference. Use table of comet data provided or input your own.
- Halley's position in sky calculated for any date, time, latitude and longitude for 1985/86 return. Gives altitude and azimuth plus indication of sun's position.
- Halley/Sun/Earth encounter. For any Halley return, past or future, calculates and plots path of Halley and Earth around the sun, point-by-point in time. Fascinating to watch!

COMETWATCH is a must for all astronomers.
Only $29.95
ORDER TODAY!
MEMBER DIRECT MARKETING ASSOCIATION
JOIN OUR THOUSANDS OF SATISFIED CUSTOMERS
U.S. orders add $2 shpng/hndlg., overseas $4. VISA/MC orders by phone or mail (give # & exp. date). PA add 6%.

ZEPHYR SERVICES
306 S. Homewood Ave., Dept. B
Pittsburgh, PA 15208
412-247-5915
MasterCard VISA
Order by phone 9 AM - 9 PM Mon-Sat
Our 4th Year of Business
FREE Software Catalog-Call/Write

HALLEY'S COMET
BOTSWANA
AND SOUTHERN AFRICA

Join a select group travelling to Southern Africa on this once in a lifetime astronomical event. Respective tours include lecture at local planetarium/observatory. Highlights include visits to the Okavango Delta, Makadikgadi Salt Pans, Victoria Falls and Chobe National Park. Supremely dark skies free of smog and light pollution.
17 and 20 day tours fully escorted by H.R. MacMillan Planetarium (Vancouver, Canada) astronomer/lecturer/anthropologist. Departures ex New York.

TFC TOURS
500-1200 W. Pender Street
Vancouver, B.C. V6E 2S9
Tel: (604) 681-6345
Toll Free 1-800-663-1330
International Offices.

TEXAS NAUTICAL REPAIR CO.

Authorized Meade Dealer

COME AND SEE
THE FINE TELESCOPES AND ACCESSORIES BY MEADE IN OUR SHOWROOM. WE HAVE IT ALL AND OTHER POPULAR MAKES

2129 Westheimer
Houston, Texas 77098
(713) 529-3551
Master Card   American Express   Visa

SPACE SHUTTLE™
THE GAME

SPACE SHUTTLE
THE GAME

NEW
exciting game about our solar system.

Mail check or money order to:

SAUNDERS GAME CORP.
P.O. Box 988, Keene, NH 03431
$14.95 + $2.00 shipping & handling

NEW LITTLE BIG GIANTS ARE HERE!

These nights, giant binoculars are *A NECESSITY*. At 1210 grams, our multi-coated, Roof-Prism **LBG 9x63's** are a cleaner, leaner Giant. More expensively built, they handle and look smarter. Instead of Black "Leatherette" coverings, we've provided the legendary durability, beauty & water/shock resistance of **RUBBER ARMOR.**

PERFORMANCE? These slimmer Roof-Prism Giants deliver STUNNING deep-space vistas, rivaling 80mm's at any price.

Another Big Bonus: the HUGE 6+° field. Compare that to the 4.5° of 11x80 or 3.5° of 20x80. Halley's Comet, Sagittarius, the Andromeda Galaxy, IRAS-ARAKI, etc. need the 6+° field. You'll happily see the difference!

What do users say? "M-33's spiral arms, M-31's dust lanes, Pleiades Nebulosity, and FEATHERWEIGHT — AMAZING!" "The LBG's are easily more of everything we wanted." "I saved hundreds and my wife loves them." "THESE ARE THE FUTURE."

The **LBG 963** lists for only $227.50. BUT ORDER NOW AT INTRODUCTORY PRICE of $158.50 and we'll INCLUDE packing, insurance and PRIORITY AIRMAIL for 3-day delivery anywhere in the U.S.A.

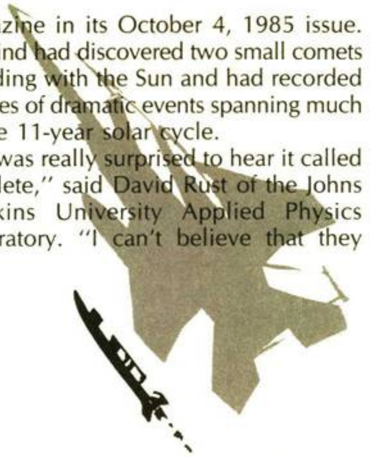
PHONE-ORDER TOLL-FREE 49 States (3-minute limit, please).
30-DAY MONEY-BACK GUARANTEE.

1-800-544-2237 or 907-376-0742
© 1985
ASTRO-ALASKA

Box 870349
Wasilla, Alaska 99687

magazine in its October 4, 1985 issue. Solwind had discovered two small comets colliding with the Sun and had recorded a series of dramatic events spanning much of the 11-year solar cycle.

"I was really surprised to hear it called obsolete," said David Rust of the Johns Hopkins University Applied Physics Laboratory. "I can't believe that they couldn't find a piece of space junk instead of a working laboratory."



Another satellite conducting coronal research — NASA's Solar Maximum Mission satellite — has been plagued by electronic problems that have made it inoperable for much of its five years in orbit. The Solar Max choronograph does not take photos of the entire corona, as did the Solwind choronograph. This makes it more difficult to correlate the data from Solar Max with interplanetary phenomena.

Third Star Discovered In T Tauri System

Although the Sun and its solar system formed 4.6 billion years ago, starbirth still occurs throughout much of our Galaxy. After being created in huge gas clouds, most stars take millions of years to ignite their fuel and reach the main sequence. One of the most famous pre-main-sequence stars is the variable T Tauri. T Tauri is, in fact, the prototype of an entire class of pre-main-sequence stars that vary irregularly in brightness.

It therefore came as something of a shock when scientists announced in 1982 that T Tauri itself was a double rather than a single star. Astronomers detected a source emitting infrared and radio radiation 0.6 arc-seconds south of T Tauri that they believed was also a pre-main-sequence star. Since its temperature was only about 800 Kelvins, the object emits very little optical radiation and has never been seen at visual wavelengths.

Now another team of astronomers has found a *northern* companion to T Tauri. If the new component is also a star, it makes T Tauri a triple star system. Unlike T Tauri's southern companion, the northern one is optically visible. Peter Nisenson, Robert Stachnik, Margarita Karovska, and Robert Noyes, all of the Harvard-Smithsonian Center for Astrophysics, reported the discovery, made using optical speckle imaging, in the October 1, 1985 issue of *Astrophysical Journal Letters*.

The new companion is 4.3 magnitudes fainter than T Tauri at visual (yellow) wavelengths and lies 0.27 arc-seconds north of T Tauri. Since T Tauri is about 520 light-years from the Sun, this translates into a projected separation of 43 AUs — the approximate distance from the Sun to Pluto. The true separation, of course, could be much more since T Tauri and its northern neighbor may not be exactly the same distance from us.

Although it is possible that T Tauri North is only a jet of ejected material from T Tauri, the researchers think it more likely that the newly discovered companion is another pre-main-sequence star. They estimate its temperature to be 3,000 K, placing the star between spectral types M-4 and M-8, and they believe its mass is between 0.2 and 0.35 solar masses. Although we know of many low-mass main-sequence stars, this estimate makes the newly discovered star one of the least massive *pre*-main-sequence stars ever detected. *Ken Croswell.*

Meteor/Earth Collision Theory Supported by New Discovery

A worldwide layer of soot found in sediments dating back 65 million years could have been produced by global wildfires ignited by the impact of a large meteorite, according to chemists at the University of Chicago. Such massive fires would have produced a "nuclear winter" that may be responsible for the extinction of the dinosaurs and most other life.

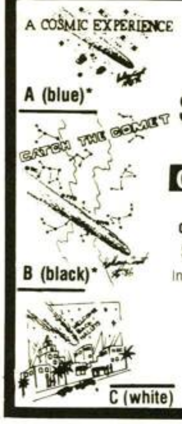
The researchers — Wendy Wolbach, Roy Lewis, and Edward Anders — reported their findings in the October 11, 1985, issue of *Science*. Their work is based on the discovery of elemental carbon in sediments from Denmark, Spain, and New Zealand. The carbon found was in a form resembling smoke from forest fires — irregular, fluffy clusters made of spheres less than a micron (1/25,000th of an inch) in size.

According to the scientists, "The large amount of soot suggests either that much of Earth's vegetation burned down or else that substantial amounts of fossil fuels were ignited."

The soot was discovered while the chemists were searching for traces of noble gases such as neon and xenon that could have been deposited by the impact of a meteorite. Lewis and his colleagues had previously shown that these gases, which are characteristic of meteorites, normally reside in grains of carbon. No noble gases, however, were discovered in the carbon. This suggests that very little of the meteorite survived the impact.

In recent years, other research has suggested that the impact of a meteorite could have caused a cloud of dust to envelope the Earth and block out the Sun's rays for months. This new discovery, however, suggests that the duration and extent of the "nuclear winter" was much greater than previously predicted.

MOTOFOCUS
REMOTE CONTROL FOCUSING
End the focusing wiggles —
Fantastic for astrophotography!
Celestron C-60, C-70, C-80, SP-90, C-100, SP-102 .... $79.95
Celestron C-5, C-8 (0-15 rpm) $89.95
(Specify age of scope)
C-11 (0-12 rpm), **C-14** (0-6 rpm) $99.95
Meade 2080, 2120 (0-12 rpm) $99.95
Coulter Odyssey, **Meade** Newtonian & refractor, **Novak, Parks, Cave, & University Optics** $79.95
Deluxe Motofocus for C-14 ...... $149.95
Control R.A., Dec., and focus all in one hand unit. Plugs into drive base.
VISA, MC, check OK. We pay postage any place on planet Earth. Foreign: send bank check US $.
JIM'S MOBILE IND., 1960 Co. Rd. 23
Evergreen, CO 80439 (303) 277-0304



GLOW WITH HALLEY WEAR!
T-SHIRTS $9.95
SWEATSHIRTS $16.95
GLOW IN THE DARK*
Deluxe 5-Color Designs
on quality heavyweight shirts
S, M, L, XL specify A, B, C
Include $1.50 Shipping & Handling
SEND TO:
Liteworks
P.O. BOX 18-1285
CORONADO, CA 92118
(619) 435-4687

NEW ENGLAND ASTRO-OPTICS, INC.
• QUESTAR • MEADE • TELEVUE •
BUSHNELL/BAUSCH & LOMB • JSO
COULTER • CELESTRON • LUMICON

master charge
VISA
CATALOG PACKAGE $2.00
Box 834, Simsbury, CT 06070
203-658-0701
TCU 685 • OUR 3rd YEAR • 70055,205

THE HALLEY COMMEMORATIVE COIN!

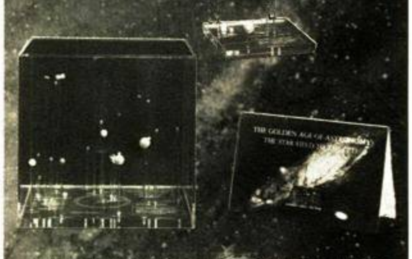
SIR EDMOND HALLEY DISCOVERER
1656-1742
actual
size 1.5"

Celebrate the passing of this great Comet with a gift to remember. A limited edition collector's coin minted on fine jewelers bronze. Delivered complete with handsome display case.

To order: Send $9.95 to:
Visa/MC orders
Please Give Card No.
And Exp. Date

RCK SCIENTIFIC
P.O. Box 140
Sissonville, WV 25360
(304) 984-3525

Halley's Comet
Voyager-Uranus
The Hubble Scope Deployment
ASTRONOMY'S GREATEST YEAR HAS ARRIVED!

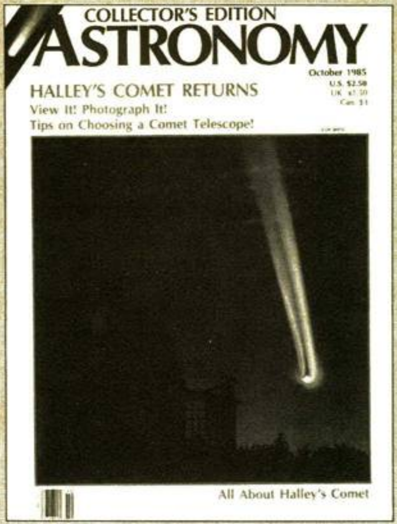


3-DIMENSIONAL STAR MAPS
Our TAU CETI projection has been reviewed and updated by astronomers on two continents. Our booklet has also been brought up to 1985/86 standards. We are proud to say that we have already satisfied hundreds of customers worldwide, and would like you to participate in this historical process.
Sol To Tau Ceti, complete (≅ 12 light-years)
8" x 9" w/ 27 stars $28
Sol To Sirius, complete (≅ 9 light-years)
4½" x 6" w/ 9 stars $15
Map is acrylic based with color coded stars.
(32-page booklet included with either projection)
The Star Field to Tau Ceti (booklet only) ... $4
"How to Build Dust-Protectors" (plans only) .. $2
Please add $3 for Canada/$12 for Overseas.
Send check or money order to:
American Tool & Toy
7800 East Jefferson #711
Detroit, MI 48214
Please [illegible] your name and address, and allow 2-4 weeks for de[illegible]

COMET HALLEY T-SHIRTS

halley
1985
1986
COMET
COMING SOON TO YOUR LOCAL PLANET!
1985 86
COMET halley
1985 86 TOUR GUIDE

Style #201
This Unique Design is an Inversion. Turn it Upside Down.
Style #203
White Designs Silk Screened on Quality Royal Blue or Black Shirts. ONLY $8.50 (PPD)
Style #211
Specify Style #, Color and Size S, M, L, XL
Send Check or Money Order To
HALLEY PRODUCTIONS
4426 Maryland Dr • Madison, WI 53704
(608) 249-2161
For Other Comet Halley T-Shirt Designs and Novelties Send for Our FREE CATALOG.


COLLECTOR'S EDITION
ASTRONOMY
October 1985
HALLEY'S COMET RETURNS
View It! Photograph It!
Tips on Choosing a Comet Telescope!
All About Halley's Comet

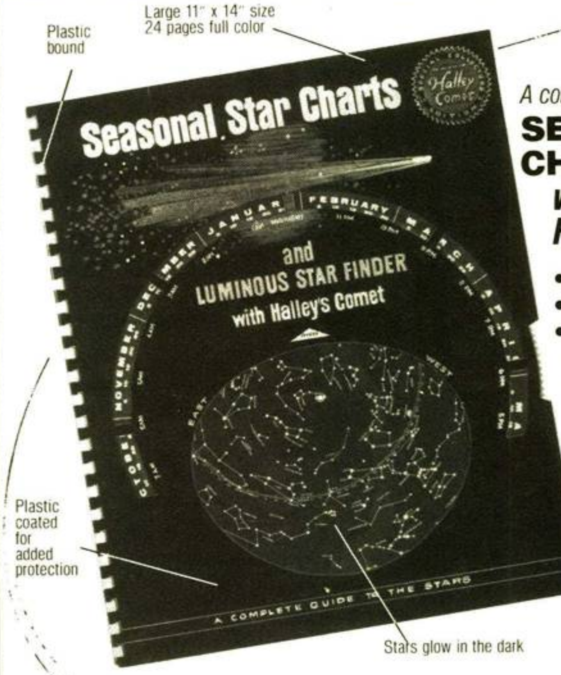
DON'T MISS IT!

HALLEY'S COMET COLLECTOR'S EDITION

Did you miss ASTRONOMY's October 1985 issue? It's the biggest-ever issue of ASTRONOMY (144 pages), and it's chock-full of useful information about viewing the return of Halley's Comet, choosing a comet telescope, and the pleasures of star gazing that can be yours long after the comet has faded to invisibility. Perfect for astronomy clubs, schools, planetaria. Don't miss this exciting, information-packed issue of ASTRONOMY. Educators and retailers, call Susan Poole at (414) 276-2689 for bulk rates.

ASTRONOMY Halley's Comet Collector's Edition $3.95
(October 1985 Issue)

To order, use the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.


Large 11" x 14" size
24 pages full color
Plastic bound
Seasonal Star Charts
Halley Comet
and
LUMINOUS STAR FINDER
with Halley's Comet
A COMPLETE GUIDE TO THE STARS
Plastic coated for added protection
Stars glow in the dark

A comprehensive
SEASONAL STAR CHART BOOK
with Halley's Comet Finder

- 24 Star Charts and Tables
- Halley's Comet Finder
- Luminous Star Finder

An informative and lasting astro-guide and unique Halley's collectors item for only $9.95.

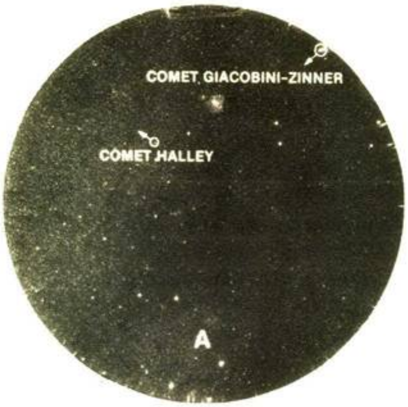
LIMITED HALLEY'S COMET COLLECTORS EDITION
$9.95
Plus $1.00 Postage & Handling

Gives location and magnitude of Halley's Comet as it passes by earth in 1985 and 1986. Provides star and constellation data for naked eye, binocular and telescope viewing. Includes star finder with stars that glow in the dark for outdoor night time use.

ORDER TODAY...available only as long as inventory lasts

Send check, money order or credit card info (number, expiration date & authorized signature) for **$9.95 plus $1.00** for shipping and handling to—

HUBBARD SCIENTIFIC
P.O. Box 104
Northbrook, IL 60062


COMET GIACOBINI-ZINNER
COMET HALLEY
A

During the middle of September, a rare close encounter occurred: Comets Halley and Giacobini-Zinner appeared to pass within less than two degrees of each other though they were actually far apart in space. These photographs, made with the 18-inch Schmidt camera at Palomar Observatory, show the event. Photo A was made on September 12th, photo B on the 13th, and photo C on the 14th. At the time, Giacobini-Zinner shone at 8th magnitude and Halley at 14th. Courtesy Palomar Observatory.

"E.T." Phone Harvard

Film director Stephen Spielberg has funded a multimillion channel radio receiver operated by the Planetary Society that will seek signals of extraterrestrial life in the Universe.

Located at Harvard University's Oak Ridge Observatory, the 8.4 million-channel receiver was switched on by Spielberg on September 29, 1985. "I'm very happy to be involved in this project," Spielberg said. "I've dedicated myself so much to science fiction that I thought it was time to get involved in some science reality."

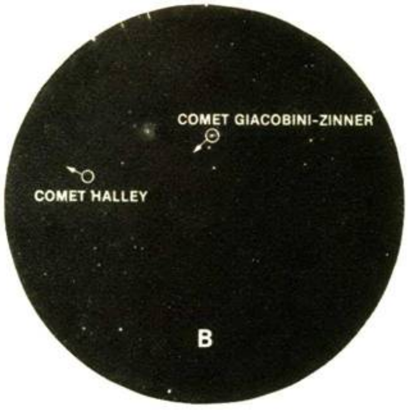
The receiver, named Megachannel Extraterrestrial Array (META), was designed and built by Harvard physicist Paul Horowitz. META will be able to search for 64 times as many channels as the Planetary Society's previous receiver, Project Sentinel.

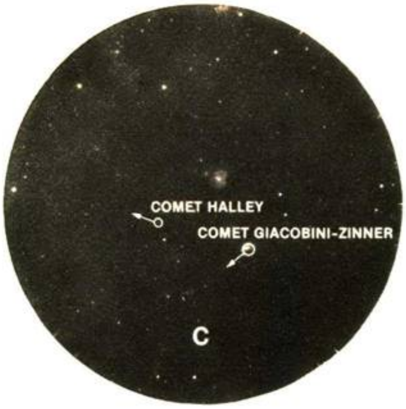
Spielberg's gift of $100,000 was used to improve the capability of the receiver system used under Project Sentinel. It was made with the provision that the Society fund the search for extraterrestrial signals over the next several years.

Halley Hot Line

For observers who can't get enough information on the whereabouts of Halley's Comet, Cornell University has established a Halley telephone hot line. By calling (607) 256-4992, you can hear a recorded message describing the comet's current position and appearance.

Callers should keep in mind that the observing information is oriented to Central New York skies and the call is not toll-free.





ASTRONOMY AstroCalendar

January 18, 1986
Halley's Comet Return-Uranus Flyby Celebration Day, East Texas State University, Commerce, Texas. Contact: Dr. John Lamb, Jr., 2812 McCarley, Commerce, TX 75428.

February 7-10, 1986
Second Annual Winter Star Party, sponsored by the Southern Cross Astronomical Society, Everglades National Park, Florida. Contact: Pat D'Auria, 1051 N.W. 145 St., Miami, FL 33168. Phone (305) 685-6001.

February 15
Electronics Oriented Astronomy 2 (seminar presented by the Orange County Astronomers), Cypress, California. Contact: Charlie Oostdyk, P.O. Box 1762, Costa Mesa, CA 92628. Phone (714) 639-8446.

March 26-29
National Convention of the National Science Teachers Association, San Francisco, California. Contact: Matthew R. Murphy, NSTA, 1742 Connecticut Ave., N.W., Washington, DC 20009. Phone (202) 328-5800.

April 11
International Halley Day of Harmony. For more information, contact: James B. Harris, Jr., Florida Space Week Committee, P.O. Box #291, Sharpes, FL 32959. Phone: (305) 632-9139.

April 18-19
Wisconsin Society of Science Teachers Annual Spring Convention, Appleton, Wisconsin. Contact: Floyd R. Henschel, 504 W. Maple Ave., Beaver Dam, WI 53916. Phone (414) 885-4415 weekdays or (414) 887-1215 evenings.

April 19
Astronomy Day. For more information, contact: Gary Tomlinson, Astronomy Day Coordinator, Astronomy League, Chaffee Planetarium, 54 Jefferson S.E., Grand Rapids, MI 49503. Phone (616) 456-3985.

May 5-10
Texas Star Party, Prude Ranch, Fort Davis, Texas. Contact: Carol Rodgers, 128 N. Commerce, Burleson, TX 76028.

June 19-21
IAPPP Symposium on Photoelectric Photometry, Mercyhurst College, Erie, Pennsylvania. Contact: Robert C. Reisenweber, Rolling Ridge Observatory, 3621 Ridge Parkway, Erie, PA 16510. Phone (814) 899-2560.

June 22-26
168th Meeting of the American Astronomical Society (professional meeting), sponsored by Iowa State University, Ames, Iowa. Contact: AAS, 1816 Jefferson Pl., N.W., Washington, DC 20036.

June 29-July 4
International Planetarium Society Eighth Biennial Conference, Tucson, Arizona. Contact: IPS Conference Committee, Flandrau Planetarium, University of Arizona, Tucson, AZ 85721. Phone (602) 621-4515.

July 12-17
98th Annual Meeting of the Astronomical Society of the Pacific, University of Colorado, Boulder, Colorado. Contact: A.S.P., 1290 24th Ave., San Francisco, CA 94122. Phone (415) 661-8660.

July 16-24
Space Week '86. For more information, contact: James B. Harris, Jr., Florida Space Week Committee, P.O. Box #291, Sharpes, FL 32959. Phone (305) 632-9139.

Meeting notices to appear in AstroCalendar must be submitted at least four months in advance of the meeting date. Most organizations appreciate your enclosing a long (business-size) self-addressed, stamped envelope along with your request for information.

AT LAST . . .
ILLUMINATED SETTING CIRCLES

LUMICIRCLES

Finally, light up your setting circles with small, easy-to-install lights without bulky wires or big metal battery cases.

70 80 90 80 70 60 50 40

LUMICIRCLES are 4 LEDS that attach without glue to your setting circles. Thin wires connect the LEDS to a small plastic case with an on/off switch and a timed two minute lights-out button.

LUMICIRCLES come complete with the following features:
- ★ 4 LEDS light up RA and DEC circle pointers
- ★ lights automatically go out after 2 mins
- ★ requires no modification to your telescope
- ★ small 9v battery operated control box has its own LED for easy location
- ★ adjustable length wires fit easily in minutes to all telescopes
- ★ control box mounts anywhere with a self-adhering back
- ★ adhesive pads for mounting wire to DEC arms and RA unit

LUMICIRCLES
MINDSTAR

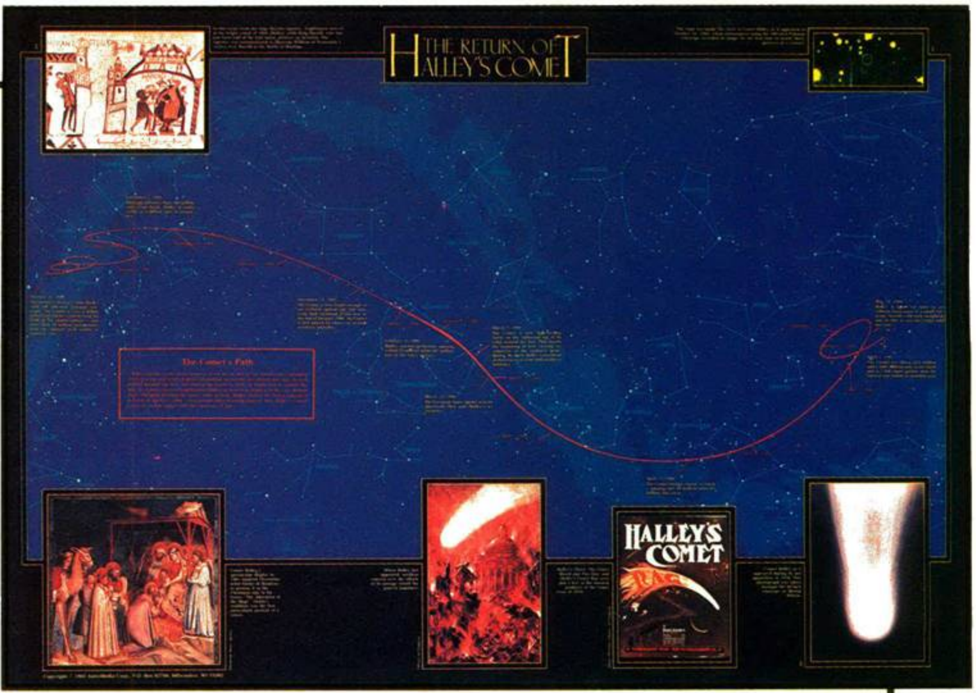
only **$49.99**
includes postage/handling & battery
CA. residents add 6% sales tax
Foreign orders, add $5.00

Available for immediate delivery.
Send check or money order to:

MINDSTAR
1001 SIOUX CT.
FREMONT, CA 94539
(415) 490-5543 or
(415) 490-1043

Display Comet Halley On Your Wall

- Accurate
- Scientific
- Historic
- Useful
- Handsome
- Unique



Now that Halley's Comet is here, keep up-to-date on where it is with **THE RETURN OF HALLEY'S COMET** from AstroMedia. Measures 21" x 30", suitable for framing. Order now!

THE RETURN OF HALLEY'S COMET

$4.95

Dealer and premium inquiries welcome. **Gift Idea: Buy 2 — Get a 3rd FREE!**

To order, use the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

EASY TO ORDER . . . Phone or mail your order in today. Visa/Mastercards accepted. All telescopes and mounts are shipped shipping charges collect. All mirrors, except the 29", are shipped prepaid in the contiguous U.S.A. No sales tax on out-of-state orders. FREE LIST.

Showroom address: 54140 Pinecrest Road, Idyllwild
Mon.-Fri. 8 am-4:30 pm. Sat. 12-4 pm.

ODYSSEY

Visual High Fidelity Telescopes

- 30 days returnable
- 30 days exchangable
- 2 years materials and workmanship

"NEVER TOO SMALL"

NEW! ODYSSEY 8 INCH

$239.50

"THE WORLD'S GREATEST TELESCOPE VALUE!"*

SPECIFICATIONS

- 8" f/4.5 paraboloidal mirror with matching diagonal flat, both 1/8 wave, aluminized and overcoated.
- Super smooth and stable Dobsonian alt-azimuth mount with linear U.H.M.W. bearings. No play or backlash.
- Adaptable to astrophotography with accessories.
- Coated high performance 27mm Kellner eyepiece with chromed brass and cast aluminum 1¼" rack-and-pinion focuser.
- Durable solid white seamless plastic vinyl tube.
- Adjustable ventilated push-pull shock resistant mirror cell.
- Beautiful black, white and metallic finish.

*Aperture is the key to performance. More aperture means more light and more resolution. In comparing all the small and medium size telescopes advertised in both Astronomy and Sky and Telescope magazines, we discovered that the Odyssey 8 has the lowest cost per sq. inch of aperture. The results were dramatic! One popular 4⅛" telescope costs $14.92 per sq. inch—3 times the cost of the Odyssey 8's $4.76 per sq. inch!

LARGE APERTURE

LARGE APERTURE is the key to the success of these fine telescopes. In their sizes, they are the largest-selling low-priced telescopes in the world today.

- 1/8 wave mirror optics
- Super smooth and stable Dobsonian mounts
- Adaptable to astrophotography with accessories
- High performance coated 27mm Kellner eyepiece with precision 1¼" focuser
- Beautiful Zolatone blue finish accented with black and metallic surfaces

10.1" ODYSSEY COMPACT

This scaled-down version of the Odyssey I performs very close to its larger brother. Because of its size, it is one of a few telescopes that can be used comfortably by an observer seated in a chair. Where space, size, weight and cost are considerations, this telescope will easily put you in the large aperture class. Fantastic views of galaxies, nebulae and star clusters are the menu of the telescope.

$299.50

13.1" ODYSSEY I

This is the telescope that started it all in the spring of 1980. Experienced deep-sky observers will tell you that you'll be amazed at what you can see under a good night sky. The challenge is not to see the lime-greens in M-42, but to detect the purple-pinks, the yellow-greens, and the subtle blues. In this size telescope there is not another available that gives you so much performance at such a low, low price.

$499.50

17.5" ODYSSEY II

Here is an unusual telescope at a low, low price. The core of this telescope is the world's most popular large aperture mirror set—the famous 17.5" f/4.5. Until recently this telescope sold for $1,195.00. We reduced the price $200.00. At $995.00 it is only $335.00 more than the mirror set! Shows colors in the Ring Nebula, two or three dust lanes in M-31, and globular clusters as they should be seen.

$995.00

29" ODYSSEY 29

The world's largest production telescope. It was with this telescope that we first saw color in the Veil Nebula. This telescope gives the observer an illusion of being in space more powerful than any other telescope we've observed with. Literally outperforms any other production telescope available in the world today.

$3495.00

Coulter Optical Co.

Dept. A, P.O. Box K
Idyllwild, CA 92349
714/659-4621

"OPTIMUM OPTICS AT MINIMUM COST SINCE 1967"

ASTRONOMICAL OPTICS

Lightweight Mirror Optics at Low, Low Prices: Pyrex, ⅛ wave, aluminized & overcoated

13.1 inch f/4.5 mirror	$254.50
12.5 inch f/6 mirror	$249.50
10.1 inch f/4.5 mirror	$134.50
10 inch f/5.6 mirror	$129.50
29 inch f/4.5 mirror	$2490.00
with diagonal	16-1 Ratio
17.5 inch f/4.5 mirror	$659.50
with diagonal	13-1 Ratio

Elliptical Diagonals

1.83"	$15.50	3.10"	$34.50
2.14"	$18.95	4.25"	$69.50
2.60"	$22.50	6.25"	$150.00

NEW! EQUATORIAL MOUNTS

- All metal
- 2" dia. shafts
- Hollow polar shaft
- Adjustable latitude
- Super sturdy, yet lightweight
- Single arm 10.1" mount
- Double arm 13.1" mount

Compact—$249.50

Odyssey I—$379.50

NASA Emblems

from ASTRONOMY-Manufactured by the Official NASA Supplier

Wear these historic colorful patches on your jacket or cap, or display them in frames — either way you'll be proud to show them.

SPACE SHUTTLE MISSION

CHALLENGER
BRAND GIBSON McCANDLESS McNAIR STEWART

STS 41B

HART VAN HOFTEN NELSON
CRIPPEN SCOBEE

STS 41C

HARTSFIELD COATS
MULLANE HAWLEY RESNIK WALKER
DISCOVERY

STS 41D

Crippen Sullivan Leestma Ride McBride
Garneau Scully-Power

STS 41G

ALLEN FISHER GARDNER
HAUCK WALKER

STS 51A

MATTINGLY SHRIVER
ONIZUKA BUCHLI
PAYTON

STS 51C

BOBKO WILLIAMS
SEDDON GRIGGS HOFFMAN
WALKER GARN

STS 51D

SPACELAB 3
LIND THAGARD OVERMYER GREGORY THORNTON
VAN DEN BERG WANG

STS 51B

BRANDENSTEIN CREIGHTON
NAGEL
FABIAN LUCID
BAUDRY AL-SAUD

STS 51G

SPACELAB 2
FULLERTON BRIDGES MUSGRAVE ENGLAND HENIZE
ACTON BARTOE

STS 51F

ENGLE COVEY LOUNGE FISHER VAN HOFTEN

STS 51I

BOBKO
GRABE STEWART HILMERS
PAILES

STS 51J

4″ each, $4.95 each. Set of 12 Space Shuttle — $37.95

NASA
$2.95

VOY
$4.95

GAL
$4.95

SP2
$5.49

SPACELAB 2
ASTRONOMY
PHYSICS
BIOLOGY

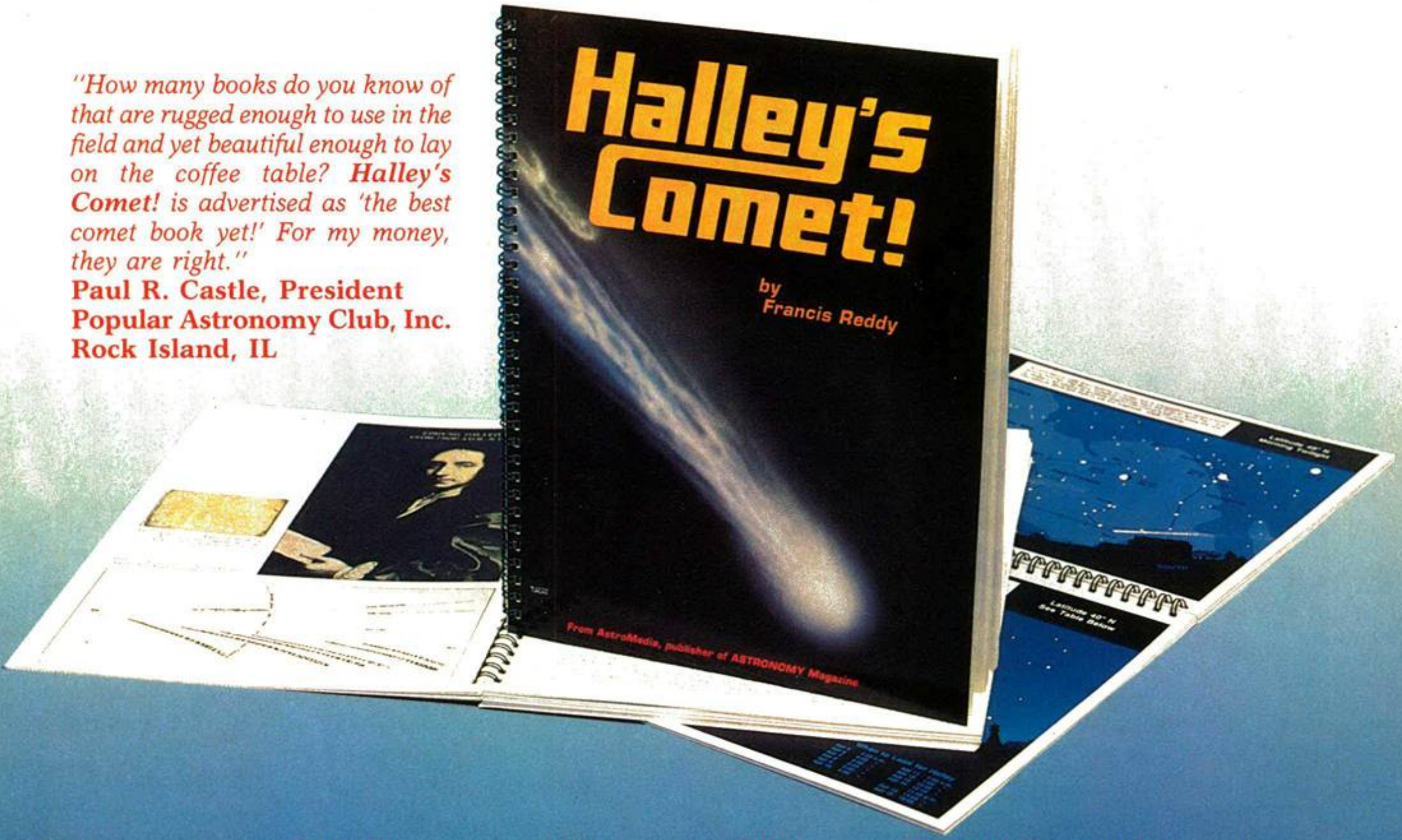
SP3
$5.49

Spacelab
3
MICROGRAVITY
NASA

To order, specify the patch code or set name on the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202

*"How many books do you know of that are rugged enough to use in the field and yet beautiful enough to lay on the coffee table? **Halley's Comet!** is advertised as 'the best comet book yet!' For my money, they are right."*

Paul R. Castle, President
Popular Astronomy Club, Inc.
Rock Island, IL



Everything You Need To Enjoy This Once-In-A-Lifetime Event

Here's your complete guide to the 1985-86 visit of this renowned comet. It's all here — comet lore and comet history, comet science, and especially comet observing! HALLEY'S COMET! includes those famous photos of the Comet taken in 1910, reproductions of historical tapestries and paintings showing the Comet, and the hilarious comet kitch soap ads and sheet music. Read all about it: how comets and meteors are related, what spacecraft will encounter Halley in early 1986 — and much, much more. *The best Halley book yet!*

Don't let Comet Halley go by without HALLEY'S COMET!

- **20 easy-to-use finder maps for northern *and* southern hemispheres**
- **Printed on heavy-duty paper**
- **Spiral bound — perfect for night-time use**
- **Make your own Halley Orbit Model**
- **Answers all your questions about Halley's Comet**
- **Over 60 illustrations (25 in color)**
- **59 pages, 8¾"x11¾"**

ONLY

$9.95

To order, use the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

ANNOUNCEMENT — Comet Halley Hotline. Talk directly with other comet watchers on this recorded message service. Contact Gary Stone, Box 153, Annapolis Junction, MD 20701.

ANNOUNCEMENT — The Raleigh Astronomy Club meets at 7:30 p.m. the second and fourth Friday of every month in Hunter Hall, Meredith College. Scientific programs and observing sessions scheduled on a regular basis. For information, please call Ward at (919) 787-5095 or write P.O. Box 10643, Raleigh, NC 27605.

FOR TRADE — Motorcycle collector will trade any of his seven motorcycles for a modern telescope in excellent condition. Contact Don Ross, 304 Walker Springs Rd., Taylors, SC 29687. Phone (803) 244-5627 nights.

FOR SALE — Startracker Celestease 8 for C8. Includes 1¼" and 2" eyepiece holders, telecompressor, 1.8x Barlow, camera mount, and diagonal mirror. Never used. Regularly $295, will sell for $175 or best offer. Contact Matthew Cheselka, W. 1808 Knox, Spokane, WA 99205. Phone (509) 328-9468.

WANTED — Correspondence with active amateur astronomers interested in theory and observation of variable stars, comets, and (super) novae search for exchange of ideas and information. Contact Ludwig Clyse, Groeneweg 5, 8898 Dentergem, Belgium.

WANTED — Space buffs to enter the "Great Shuttle Giveaway III" contest. The winner will receive a collection of space shuttle and space-related items. The entry deadline is April 2 and the drawing will be held April 15. Send name and address on 3" x 5" paper with $1 entry fee to GSG3, Florida Space Week, P.O. Box 291, Sharpes, FL 32959.

WANTED — 6" to 12" reflector. Must be very reasonable; can be in need of repairs. Contact Cindy Bernard, 1025 Meadolark, Merritt Island, FL 32953.

HALLEY'S COMET
1 9 8 6

COMMEMORATIVE T-SHIRT

Design silk screened on red, white, blue, or orange shirt

Mens S.M.L.XL. Specify Jr. sizes

$8.50 **2 for $15.00**

MARCOTT DESIGNS
123 Highland Street S. Easton MA 02375

NEW ZEALAND and HALLEY'S COMET
Leave from LA on 3-31, return on 4-15-86

$2687 includes Air, Hotels, tour of N.Z., and many meals. Visit the National Observatory, and meet local Astronomical Societies. Stay one night with farm families on Rotorua.

Trip leaders: Cynthia and Ron Allison through
Travel Reps of Los Angeles
209-931-6095 or
P.O. Box 4026, Stockton, CA 95204

HALLEY 86

The T-Shirt of the Century!
A Cosmic Collector's Item!

Star-Brite-White on
Deep-Midnight-Blue
Made in U.S.A.

Adult Sizes: S-M-L-XL
Only $7.50 Postage and
Handling Included!

Send check or money order to:
Pro Skreen Printing
230 Hickory St.
Edwardsville, IL 62025

Please allow 2 to 3 weeks delivery. And THANKS!

TeleVue Optics from Optics Ohio

Plossls 50° field (except 40mm)

Focal Length	O.D.	Price
55 mm	2.00"	$175
40, 32 mm	1.25"	95 each
26, 21, 17, 13		
10.4, 7.4, 2.5x	1.25"	80 each
New!! 1.8x Barlow	1.25"	80

Naglers
82° Field of View

	13 mm	2/1.25"	$235
New!!	11 mm	2/1.25"	225
	9 mm	2/1.25"	210
New !!	7 mm	1.25"	175
	4.8 mm	1.25"	140

Wide Fields
65° Field of View

	40 mm	2.00"	$265
	32 mm	2.00"	210
	24 mm	1.25"	140
	19 mm	1.25"	125
New!!	15 mm	1.25"	110

SPECIAL OFFER: Any TeleVue order of $175 or more will receive FREE Sky Atlas 2000 Deluxe ($35 value).

Offer good through February 15, 1986

Add $3.00 for postage - Foreign orders add $10.

OPTICS OHIO
"A Division of Cosmic Connections, Inc."
P.O. Box 1439, Lancaster, Ohio 43130
Telephone inquiries accepted at our corporate office
312-851-5353

NASA VIDEO
THE REEL STUFF

ONE HOUR HIGHLIGHTS OF MANNED MISSIONS — $29.95
ALL DIRECT TV TRANSMISSIONS FROM APOLLO 10 — 17,
SKYLAB, ASTP AND SHUTTLE ... SEND FOR DETAILS

BETA OR VHS AMERICAN NTSC STANDARD ONLY

AVD SERVICES
767 ST. MICHAELS DRIVE
MITCHELLVILLE, MD 20716

ADD $2.00 SHIP/HAND $3.50 P.O. BOX OR CANADA

RENAISSANCE™
By TeleVue

TeleVue Eyepieces
- **Nagler**
- **Wide Field**
- **Plossl**

CELESTRON®
PRECISION OPTICS

TELESCOPES & ACCESSORIES
CALL OR WRITE FOR INFORMATION

Bergen County Camera
270 Westwood Ave.
Westwood, NJ 07675
201-664-4411

BEST VIEW OF COMETS AND MILKY WAY? BINOCULARS!

World's Largest selection at competitive prices - Swarovski, B&L, Zeiss, Leitz, Fujinon, Meade, Edmund, Steiner, Swift, Nikon & Mirador. Giant Military Binoculars - New & Used. Free Binocular Catalog - or $2.00 ($4.00 - Foreign) for Giant Binocular - Telescope Catalog. M/C-Visa.

Mack Optical & Machine Tool
P.O. Box 541-AT, Scranton, Pa. 18501
(717) 961-2542

JUST IN TIME FOR
HALLEY'S COMET
8-in, f/5 Dobsonian Kit

We supply:	You supply:
*Optics	*Construction materials
*Holder, cell	*Labor
*1.25-in Focuser	
*26mm TeleVue	$359.00 f.o.b. Aurora, IL
*Plans	Optics alone $199.00

Cosmic Focuser

*Electronic/manual focus *Easy installation
*C8 or Meade 2080 $79.95
*C11 or Meade 2120 $89.95
*All prices subject to change

Cosmic Connections, Inc.
1460 N. Farnsworth Ave.
Aurora, Illinois 60505
*Catalog $2.00 312-851-5353

ASTRONOMY
Advertisers
January 1986

Ad-Libs Astronomics 84-85
Adorama Camera Inc. 89
American Tool & Toy 77
ARCsoft Publishers 88
Astro-Alaska 76
Astroline Products 86
Astronomy Book Club 25
Astronomy Tours International 86
Astro-Physics 97
AVD Services 83
Barnes & Noble Bookstores 29,73
Bergen County Camera 83
Berger Bros. Camera Exchange 73
Bonaire Tours 86
Bushnell Optical Company 71
California Telescope Company 27,70
Celestron International 40-41,112
Cosmic Connections, Inc. 83
Coulter Optical Co. 80
Dover Photo Supply 76
Edelman's 46
Edmund Scientific 72-73
Focus Camera, Inc. 96
Halley Productions 77
Halley's World 87
Hayes & Nolly Productions 88
Horizon Productions 88
Hubbard Scientific 78
Jim's Mobile Industries 77
Journey World 89
Laboratory MicroSystems, Inc. 88
Linger, S. 86
Liteworks 77
Lumicon 52-53
Mack Optical 83
Macmillan Publishing Co. 45
Marcott Designs 83
Meade Instruments 2-3
Meteorites 89
Micro Grafix 86
Mindstar 79
New England Astro-Optics 77
New York Camera 98
Nova West Company 89
Oasis Art 87
Optics Ohio 83
Orion Telescope Center 60-61
Parks Optical 36-37,86
Pauli's Discount Optics 88
Photo Cine shop 87
Pinboys 87
Pixel Art 89
Pro Skreen Printing 83
Quasar Optics 86
Rainbow Adventure Holidays 70
Ritchey-Prints 87
RCK Scientific 77
Saunders Game Corp. 76
Scientia 75
Spectrum 89
Star Tracker 87
Stellar Visions 75
Tailwind Enterprises 87
TBR/OptiSystems 89
TeleVue 110
Texas Nautical Repair Co. 76
TFC Tours 76
Thousand Oaks Optical 88
Towson Photo Supply 89
Travel Reps of Los Angeles 83
Tuthill, Roger W., Inc. 23
Zephyr Services 76

AstroMart listings are free to all our readers for non-commercial purposes — but only 2 per person, per year, please. Limit your ad to 40 words including your name and address and allow 4 to 6 months for it to appear. All ads are subject to review for suitability. AstroMedia assumes no responsibility for statements made in classified ads, nor for the quality of advertised items.

Last chance to beat

~~$3020.00~~
$1795

2080/LX3, w/MCSO

Some telescope manufacturers have already increased prices — but we're holding the line on Meade! These low prices on some of Meade's most popular telescopes and accessories are guaranteed through February 28, subject to stock on hand. That means that if you want to save big money on a telescope and accessories, *right now* is the right time to do it!

Some telescope dealers have low prices, but no telescopes. At Ad-Libs Astronomics, we have low prices and hundreds of telescopes *in stock!*

And some dealers strip out important standard accessories, claiming they're optional and charging extra for them. At Ad-Libs Astronomics, we give you *every* standard accessory the manufacturer supplies.

So why wait for a telescope that may never be delivered (and which may be missing some parts if it ever does come?) We can ship *today* — and we include all standard accessories . . . eyepieces, finders, cases, *everything!*

And why pay up to $125 freight on an 8" telescope, as some mail order dealers charge? Our prices include *free freight*, except on credit card orders.

Want a good price on a Meade, Celestron, Edmund, or Bausch & Lomb telescope — one that comes with *all* accessories, *free freight*, and can be shipped *now?* We have what you want. Just look . . .

Authorized Meade Dealer

MEADE 8" SCHMIDT-CASSEGRAINS

Our Meade Schmidt-Cassegrains include *every* standard accessory that Meade normally supplies, plus *free freight* (except on credit card orders). Just look at these bargains . . .

- **Meade 2080**: All-purpose 8" Schmidt-Cassegrain suitable for visual and photographic observations both inside and outside the solar system. With electric worm gear drive, slow motion controls, carrying case, two eyepieces, wedge, field tripod, lifetime warranty, and more! *$2250 list* .... **for $1349!**
- 2080 with high transmission coatings $1439
- **Meade 2080/LX2, with MCSO**: Advanced 8" Schmidt-Cassegrain suitable for the serious amateur astronomer and astrophotographer. With multi-coated silver optics for 23% more light than standard coated optics, deluxe electric worm gear drive, 8 x 50mm finder, two Research Grade eyepieces, wedge, field tripod, deluxe latitude adjuster, lifetime warranty, and more! *$2670 list* .... **for $1649!**
- 2080/LX2 with EMCG (enhanced mirror coatings group) for 12% more light transmission than standard coated optics $1599
- 2080/LX2 with high transmission coatings (10% more light than uncoated optics) $1549
- **Meade 2080/LX3, with MCSO**: The most sophisticated 8" Schmidt-Cassegrain available today! With multi-coated silver optics, deluxe worm gear quartz drive that operates from AC or DC, an 8 x 50mm illuminated polar reticle finderscope, two Research Grade eyepieces, piggyback camera mount, wedge, field tripod, lifetime warranty, and so much more! *$3020 list* .... **for $1795!**
- 2080/LX3 with high transmission coatings for 10% more light than uncoated optics $1695

Accessories for 2080/LX3

- $150 list #36 drive control box $99.50
- $150 list #38 declination motor $99.50
- $90 list dew cap $67.50
- $220 list off-axis guider system $149.00
- $120 list tube balance system $89.50
- $30 list map light $22.50
- $180 list 3" off-axis solar filter $134.50
- $60 list setting circle lights $44.50

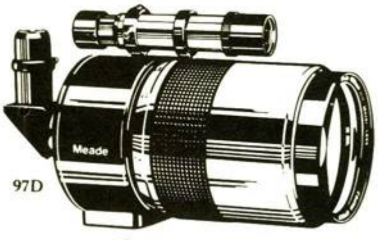
2045

~~$995.00~~
$595

Shown with optional camera and T-adapter

MEADE 4" SCHMIDT-CASSEGRAIN AND SPOTTING SCOPES

- **Meade 2045**: Compact 4" Schmidt-Cassegrain is telescope, spotting scope, and 1000mm telephoto lens — all in one! With motor drive, metal-clad case, 5 x 24mm finder, two eyepieces for 40x and 111x magnifications, coated optics, tabletop tripod, lifetime warranty, more! *$995 list* .... **for $595!**


97D

~~$650~~
$349

- **Meade 97D**: Compact Maksutov-Cassegrain spotting scope is the only reasonably-priced 3½" spotter to have high transmission coatings on its corrector lens to improve visual and photographic contrast. This 1000mm f/11 system comes with metal-clad case, 5 x 24mm finder, two eyepieces for 40x and 83x, coated optics, tripod adapter, helical focusing, lifetime warranty! *$650 list* .... **for $349!**
- **Meade 107D**: Compact 4" Mangin-Cassegrain is a fast 1000mm f/10 spotting scope and telephoto lens at a sensible price. With case, 5 x 24mm finder, two eyepieces for 40x and 111x, magnifications, micrometer focusing, coated optics, tripod adapter, lifetime warranty, more! *$750 list* ...... **for $419!**

~~$1510.00~~
$999

DS-10A

MEADE DEEP SPACE REFLECTORS

Our Meade deep space reflectors include *every* accessory Meade supplies, plus *free freight* (except on the DS-16 and on DS-10 credit card orders). Just look at these bargains . . .

- **Meade DS-10A:** A 10" f/4.5 deep space reflector superb for dark sky viewing and astrophotography. With 25mm eyepiece, #680 focuser, pedestal mount, setting circles, worm gear motor drive, free freight, lifetime warranty. *$1510 list* .... **for $999!**
- $430 #47M dual axis drive corrector $299.50
- $140 #210PG guide scope w/rings $105.00
- DS-10, without motor drive $869.00
- **Meade DS-16A:** A huge 16" f/4.5 deep space reflector with incredible light grasp for serious deep space viewing and astrophotography from dark sky observing sites. With 25mm eyepiece, #680 focuser, pedestal mount, setting circles, worm gear motor drive, lifetime warranty. Shipped truck freight collect. *$3050 list* .... **for $1979!**
- $300 ball bearing mount upgrade $214.50
- $50 40 lb. counterweight substitution $37.50
- $70 casters, set of 3 .... $52.50
- $40 leveling screws, set of 3 .... $29.95
- $30 2" eyepiece extension tube $22.50
- $550 #48RS dual axis drive corrector ... $389.50
- $350 #300PG guide scope w/rings $262.00
- DS-16, without motor drive $869.00

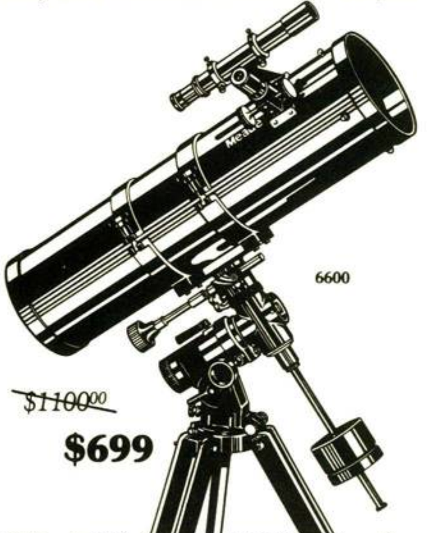
All prices good through February 28, 1986, and limited to quantities on hand.

the price increases!

MEADE REFLECTORS

Our Meade reflectors include *every* accessory Meade supplies, plus *free freight* (except on credit card orders). Just look at these bargains . . .

- **Meade 826C:** Best all-around value 8" f/6 Newtonian reflector. Super for planetary/deep space visual and photographic work. With two eyepieces, 2" focuser with 1¼" adapter, 8 x 50mm finder, pedestal mount, leveling screws, latitude scale, latitude adjuster, setting circles, worm gear drive, free freight, lifetime warranty. *$1530 list* . . . . **for $999!**
- **Meade 645C:** Compact 6" f/5 Newtonian reflector great for deep space viewing and photography, high quality lunar and planetary observing. All the accessories and features of the 826C, above. Free freight, lifetime warranty. *$1370 list* . . . . **for $899!**
- **Meade 628C:** A 6" f/8 Newtonian reflector designed for superb high power lunar and planetary observing and photography, plus considerable deep space viewing. All the same accessories and features as the 826C, above. Free freight and lifetime warranty. *$1350 list* . . . . **for $889!**



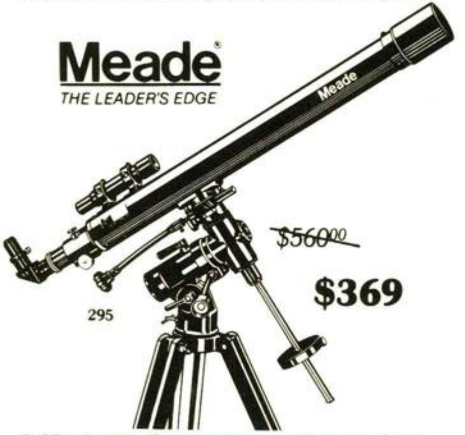
- **Meade 6600:** A compact 6" f/5 Newtonian reflector loaded with features for all-around great performance. With two eyepieces, 6 x 30mm finder, adjustable-height tripod mount with slow motion controls, metal tube assembly and dust cover, latitude adjuster, setting circles, free freight, lifetime warranty. *$1100 list* . . . . **for $699!**
- **Meade 8800:** An 8" f/4.5 rich field Newtonian reflector designed for sensational deep space visual and photographic work. With all the features and accessories of the #6600, above. Free freight, lifetime warranty. *$1400 list* . . . . **for $899!**
- $220 list #784 single axis quartz motor drive and drive corrector for the #6600/8800 . . . . $164.50

MEADE REFRACTORS

Our Meade refractors include *every* accessory Meade supplies, plus *free freight* (except on credit card orders). Just look at these bargains . . .

- **Meade 226:** A good 2.4" altazimuth for the beginner who wants good lunar, planetary, and terrestrial views at a low cost. With two .965" eyepieces, altazimuth mount, tripod, 5 x 24mm finder, free freight, lifetime warranty. *$300 list* . . . . . **for $179!**

Meade®
THE LEADER'S EDGE



- **Meade 291:** Quality planetary observing from a bargain-priced 2.4" equatorial refractor. With two .965" eyepieces, equatorial mount and tripod, setting circles, slow motion controls, 6 x 30mm finder, free freight, lifetime warranty. *$460 list* . . . . . **for $319!**
- **Meade 300:** Fine 3.1" equatorial refractor performance at a sensible price. Exceptional for lunar and planetary observing. With three .965" eyepieces, equatorial mount and tripod, setting circles, slow motion controls, 6 x 30mm finder, free freight, lifetime warranty. *$850 list*. . . . . **for $549!**
- $120 #781 motor drive for the #291/300 . . $89.50
- **Meade 310:** A premium-quality 3.1" altazimuth refractor for the casual astronomer who wants breathtaking and hassle-free lunar and planetary views. With two 1¼" eyepieces, altazimuth mount, tripod, slow motion controls, 6 x 30mm finder, free freight, lifetime warranty. *$700 list* . . . . . **for $449!**
- **Meade 295:** An inexpensive 2.4" equatorial refractor with premium performance. With two .965" eyepieces, equatorial mount and tripod, setting circles, slow motion controls, 6 x 30mm finder, free freight, lifetime warranty. *$560 list* . . . . . **for $369!**
- **Meade 320:** A premium-quality 3.1" equatorial refractor at a far from premium price. Exceptional for planetary observing. With two 1¼" eyepieces, equatorial mount and tripod, setting circles, slow motion controls, 6 x 30mm finder, free freight, lifetime warranty. *$900 list*. . . . . **for $599!**
- $220 list #784 single axis quartz motor drive and drive corrector for the #295/320 . . . . $164.50

~~$399.00~~
11 x 80mm
$229

MEADE BINOCULARS

For many people, the best view of Halley's Comet will be through Meade giant astronomical binoculars. Their 80mm objectives gather as much light as two 3.1" telescopes, for crisp, bright, wide field views of star clusters, nebulae, and galaxies — as well as comets. Each comes with lens caps, case, carrying straps, and a photo tripod adapter (tripod optional, but highly recommended). The 11 x 80 model is best for dark sky observing sites, while the 20 x 80 model is best for observing from the city or suburbs. Now with a lifetime warranty, too!

- $399 11 x 80mm, 4.5° field . . . . **for $229.00!**
- $419 20 x 80mm, 3.5° field . . . . **for $239.00!**

MEADE ACCESSORIES

We have low prices on Meade accessories, too; accessories that fit Meade and Celestron Schmidt-Cassegrains, plus all brands of reflectors and refractors. And we don't make you buy a telescope to get those low prices, either, as some retailers do. Just look at these examples . . .

• $220 off-axis guider system (Includes guider body and illuminated reticle.)	$149.00
• $40 T-adapter	$29.95
• $40 tele-extender	$29.95
• $40 1¼" camera adapter	$29.95
• $40 .965" camera adapter	$29.95
• T-rings for above camera adapters.	
For Pentax S, Minolta, Nikon cameras	$9.95
For Pentax K, Miranda, Exacta cameras	$10.95
For Canon, Olympus cameras	$11.95
• $120 1¼" illuminated reticle only	$79.50
• $120 .965" illuminated reticle only	$79.50
• $60 #122 2x Barlow	$44.50
• $70 #123 3x Barlow	$52.50
• $90 #124 2x or 3x Barlow	$67.50
• $80 #127 2x-3x variable Barlow	$59.50
• $60 #126 2x Barlow for 2045	$44.50
• $40 Series 2 1¼" mod achro eyepiece (Specify 6, 9, 12, 25, or 40mm mod. achro.)	$29.50
• $60 Series 2 1¼" 40mm EWF eyepiece	$44.50
• $40 Series 2 .965" mod achro eyepiece (Specify 9, 12, 25, or 40mm mod achro.)	$29.50
• $60 Series 2 1¼" ortho eyepiece (Specify 4, 6, 9, 12.5, 18, or 25mm ortho.)	$44.50
• $60 Series 2 .965" ortho eyepiece (Specify 4, 6, 9, 12.5, 18, or 25mm ortho.)	$44.50
• $90 Research Series 1¼" Erfle eyepiece (Specify 7, 12.5, 15.5, or 20mm Erfle.)	$67.50
• $80 Research Series 1¼" ortho eyepiece (Specify 4, 7, 10.5, 16.8, or 28mm ortho.)	$59.50
• $40 accessory shelf for 2080	$29.95
• $90 dew cap for 2080	$67.50
• $120 tube balance for 2080	$89.50
• $120 tube balance for 2120	$89.50
• $120 #43 single axis drive corrector	$84.50
• $240 #41 single axis drive corrector	$179.50
• $430 #46 dual axis drive corrector	$299.50
• $430 #47M dual axis drive corrector	$299.50
• $550 #48RS dual axis drive corrector	$389.50
• $15 1¼" color filters (Specify whether #8, 11, 12, 21, 23A, 25A, 47, 58, 80A, or polarizing filter.)	$10.95
• $80 #908 1¼" nebular filter	$59.50
• $150 #911 nebular filter for visual back	$109.50
• $40 piggyback for 2080	$29.95
• $40 piggyback for 2120	$29.95
• $150 wide field adapter system	$104.50
• $60 1¼" porro prism	$44.50

Free Telescope and Accessory Discount Price List

We are authorized dealers for Meade, Celestron, Questar, TeleVue, Lumicon, Bausch & Lomb Criterion, Edmund, University Optics, Olympus, Vernonscope — and more! Send a stamped, self-addressed envelope for our *free* discount price list showing your savings on the hundreds of telescopes and accessories we carry — or send $1 for our complete catalog. It's the most detailed and informative catalog available, according to our customers. It's a catalog that takes the guesswork out of picking the right telescope and accessories, and saves you money, too!

ad-libs
astronomics **Our 7th year of saving you money!**
2401 Tee Circle, Suite 106, Norman, Oklahoma 73069 *(405) 364-0858*

MasterCard, Visa, American Express. Freight additional on credit card orders. North American sales only.
Hours: Monday through Friday, 10:00 AM to 5:30 CST. Some quantities limited.

DESIGNED ESPECIALLY FOR YOUNGSTERS

**A Great Gift
for Your Child
or Grandchild**

HALLEY'S COMET 1986
I'll see it in the year 2061, too!

Beautiful Quality
Silkscreen on
Royal Blue or
Maroon Shirt
Only $8.95 (PPD)

5 Designs as well as caps.
Travel Bags & Stickers
SEND FOR FREE CATALOG

SPECIFY STYLE #505.
COLOR & SIZE
Junior: 2-4/6-8/10-12/14-16

ASTROLINE PRODUCTS
1925 Juan Tabo NE, Suite B248 • Albuquerque, NM 87112
(505) 821-1268

BONAIRE SCUBA CENTER

BONAIRE BEACH HOTEL

Halley's Comet
SEA & SKY VACATION
HASSLE FREE DIVING

800-526-2370
in N J 201 566 8866
BONAIRE, P O Box 775, Morgan, NJ 08879

WANTED — Cartin Space Foundation seeks amateur astronomers involved with, or interested in, asteroid research. CTSF is associated with the World Space Foundations' Asteroid Resource Project and Palomar Observatory. For more information, write CTSF, P.O. Box 2211, New Britain, CT 06051.

WANTED — Planetary Society and NIS member interested in finding other members in western New York and southern Ontario. Contact Emil J. Filkorn, 6438 Engel Dr., Hamburg, NY 14075.

WANTED — Astronomy 35mm slides and books including *Meteors* by Olivier and *Canon of Eclipses* by Oppolzer. Contact Tim Unruh, P.O. Box 13375, Sacramento, CA 95813. Phone (916) 451-7744.

WANTED — 8" Schmidt-Cassegrain; will pay $500 to $700. Contact Marc Roffman, 255-21 E. Williston Ave., Floral Park, NY 11001. Phone (718) 347-5988.

WANTED — Chart #12, cover, and binding for Becvar's *Atlas of The Heavens*; also chart #26 and binding for the deluxe edition of Wil Tirion's *Sky Atlas*. Contact Joseph M. Gagnon, RD 1, Box 845, Williamstown, VT 05679.

WANTED — 8" or 10" Schmidt-Cassegrain. Contact Ray Mummert, R.D. I, Box 93, Abbottstown, PA 17301. Phone (717) 259-0665.

WANTED — Correspondence with amateur astronomers. Contact John Wironen, 52 Barrel Rd., Westminster, MA 01473.

Halley's Comet Is Coming !!!

COMPUTER GENERATED MAP SHOWS :

- comet's nightly position in sky
- comet's path through sky
- orientation of comet's tail
- azimuth / altitude / dates

16 x 20 in poster - $ 5.95 + $ 1. 55 postage & handling

35 mm color slide - $ 2.00 each

Send CHECK or MONEY ORDER to :

**MICRO GRAFIX
301 WALTON AVE.
SOUTH ORANGE N. J. 07079**

... N.J. residents add 6 % sales tax ...

CANADA

CELESTRON

Catalog — $3.00

Western Canada's Largest Scope Dealer

master charge
BOOKS, FILMS and TELESCOPES
VISA

QUASAR OPTICS

*7220A FAIRMOUNT DR. S.E.
CALGARY, ALBERTA T2H OX7
(403) - 255 - 7633*

COMET HALLEY

COMMEMORATIVE NECK TIE. MADE IN ENGLAND. EXCLUSIVE LIMITED EDITON OF 1,986 TIES. First quality blue woven silk or Essex polyester, inlaid with embroidered gold/red comet motif and national flag. Each with a dated and numbered certificate. Strict order priority. Send now to ensure your allocation.

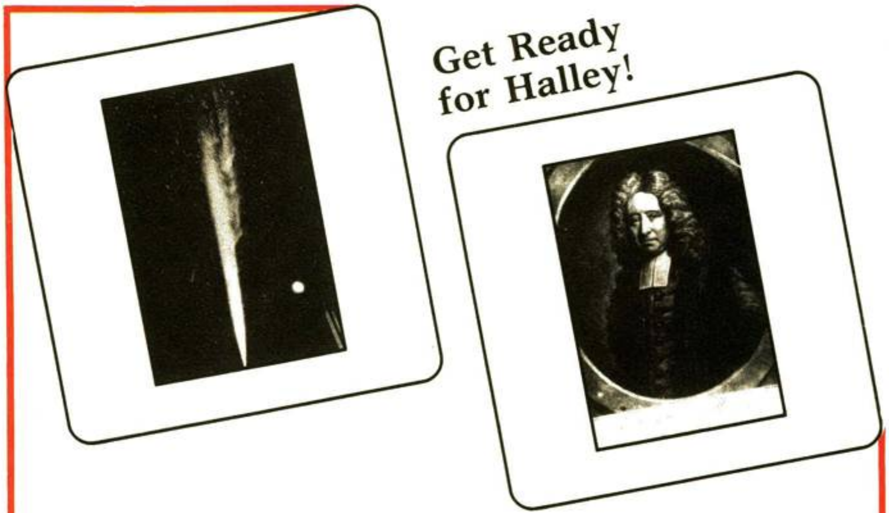
Delivery — 4 weeks

silk $29.95 (£ 22-50)
polyester $9.95 (£ 7-50)

Sterling checks or international money orders on London to:
**S. Linger, 18 Gaiger Close, Springfield
Chelmsford, Essex, England**

WANTED: Skilled Opticians with 2 years Experience Manufacturing and testing Parabolic Optics. Also Precision machinists Familiar with Telescope Equatorial mountings. Please send resume to:

**PARKS OPTICAL, 270 Easy St.
Simi Valley, CA 93065**



Comets and Comet Halley

a slide set by John C. Brandt

Are your non-astronomer friends driving you crazy with questions about "Hailey's" Comet? Do you ever wish for a set of comet slides you could haul out and show them? Or — would you like a personal pictorial souvenir of its historic return? Dr. John Brandt, noted NASA comet astronomer, has chosen 31 key slides that depict Halley's Comet and describe and illustrate the space probe missions headed for it. A 15-page informative booklet by Brandt accompanies the set. Be ready for Halley!

31 slides (17 in color), boxed with booklet. **$23.95**

To order, use the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Cometa
Halley

HALLEY'S COMET C.H.A.S.E. 86 AUSTRALIA

Travel with Mr. John E. Bortle, Mr. Daniel W.E. Green, Mr. Charles S. Morris and Mr. Tony Cook, our expedition leaders, to Australia to view Halley's Comet.

C.H.A.S.E. 86 has been designed to fill your Halley's Comet viewing requirements, both in site choices and technical support.

Viewing time of approximately 60 hours has been set aside for C.H.A.S.E. 86. When not viewing Halley's Comet and other objects in the sky of the southern hemisphere, you will have the opportunity to visit points of interest and beauty in this land down under.

For information call **(818) 505-0448** or write to **Astronomy Tours International,** 4311 Overland Ave., Culver City, CA 90230

WANTED — Antique telescope objective or complete instrument. Contact Barry Greiner, Main St., P.O. Box 24, Loysville, PA 17047. Phone (717) 789-3238.

WANTED — Coulter Odyssey 13.1" scope or optics. Will pick up anywhere in southern California. Contact Shawn Mulcahey, 6700 Independence Ave., #320, Canoga Park, CA 91303. Phone (818) 703-1352.

WANTED — Books, newspapers, magazines, news coverage, etc. on the January 27, 1967 Apollo fire; also a copy of *Starfall* by Betty Grissom and Henry Still. Contact Darrell Pipkin, 774 Turner-Warnell Rd., Mansfield, TX 76063.

WANTED — Data on celestial objects for a deep-sky book being written using only amateur observations. Visual and photographic contributions from the whole world are welcome and will be acknowledged. Contact Federico Manzini, Stazione Astronomica, Tenuta Guascona, I-28060 Sozzago (Novara), Italy.

WANTED — Declination motor and dual-axis drive corrector for Criterion Dynamax 8, $150. Phone David Tandy at (217) 965-3958.

WANTED — Color slides of southern constellations. Will buy or exchange for northern constellation slides. Would also like contact with Australian amateurs regarding observing sites near Sydney. Contact A.P. Simpson, 30551 Santa Luna Dr., Rancho Palos Verdes, CA 90274. Phone (213) 547-1250.

RARE HALLEY'S COMET
8 x 10 CONTACT PRINT

From the original photographic plate showing highly magnified comet head.

Photographed by George W. Ritchey with the 60-inch reflector at Mt. Wilson Observatory

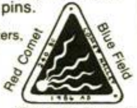
$14.95 postpaid

Ritchey-Prints, Capistrano Beach, CA
92624-0386 Tel. (213) 436-5876

HALLEY, COMET! GET IT!

The 1st pin in our 9 pin Comet Halley collection of quality cloisonne clutch back pins.

$5.50 ea. (includes tax, postage & handling)

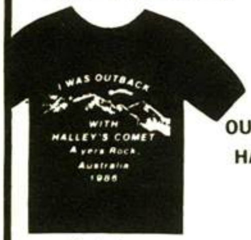


(Facsimile Drawing)

PINBOYS Box 71663
Los Angeles, CA 90071
(213) 225-PINS

Ask about our complete line of T-shirts, badges, stickers, etc.

HALLEY'S COMET T-SHIRT



Style B
OUT OF THE NIGHT
HALLEY'S COMET
1986

Style A

50/50 Navy T-Shirt - 4 Color Silk Screen - Style A/B
Sizes S • M • L • XL - $10.50/ea., includes Postage
Make Check or Money Order Payable To:
Halley's World
Box 565
Dayton, OH 45402
Allow 4-6 weeks delivery

STAR TRACKER

THE MOST COMPLETE TELESCOPE STORE IN THE KNOWN UNIVERSE

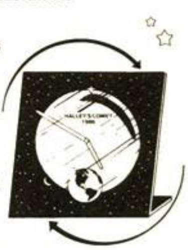
COME IN AND COMPARE

Write for the world's finest telescope Catalog and Reference Manual
$2 U.S.A. $4 Foreign

3093 WALNUT
BOULDER, COLORADO 80302
(303) 442-6805

Halley's Comet ACTION Clock
Glow-in-the-Dark

Revolving Disk
"Second Hand" Creates
Fantastic Illusion of
Moving Comet—
Every Minute!



Quality Silkscreen
Non-toxic
5" x 5" Dark Blue Plexiglas
Uses Standard House Current
1 Year Warranty

$12.50 ppd.

Send Check or Money Order to:
OASIS ART
P.O. Box 80605
Las Vegas, NV 89180

©1985 OASIS ART
MADE IN U.S.A.

"COMET HALLEY"

15 Day Tour to Australia,

March 25 - April 8

Tours to Alice Springs
Ayers Rock • Hilo, Hawaii & More

West Coast Departure

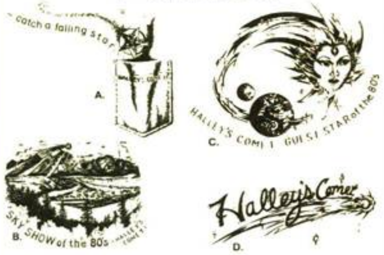
$2475.00/ea **(Based on double occupancy)**

Single rates & West Coast add-on available

Write To: Halley's World
Box 565
Dayton, OH 45402

FREE TOUR T-SHIRT

HALLEY'S COMET T-SHIRTS!



catch a falling star
A.
HALLEY'S COMET GUEST STAR of the 80's
C.
B. SKY SHOW of the 80's
Halley's Comet
D.

Participate in the event that happens just once in our lives. Choose from 4 screened designs on highest quality shirts. Your choice of tan, blue, yellow or red. Specify shirt size, color and design. Send $12.00 postpaid to:

Tailwind Enterprises P.O. Box 72728, Roselle, IL 60172

Authorized Meade Dealer

MEADE • RENAISSANCE • TELE VUE

Large selection of binoculars

Photo Cine Shop
129 South 18th Street
Philadelphia, PA 19103

(215) 567-7410

Call for mail order info and prices!

1985-86
HALLEY'S COMET

Wear the COMET with Pride!

When Halley's Comet comes by this year, let all the world know that you're a Halley Watcher! Our embroidered Halley's Comet patch features a striking blue-and-white comet on a space-blue background. The orbits of the planets, in bright yellow, are shown against the orbit Edmond Halley discovered. Order now — Halley's here! Better yet, order 2 Halley patches for $9.90 and get a 3rd FREE.

HALLEY'S COMET PATCH 2½"x5" $4.95

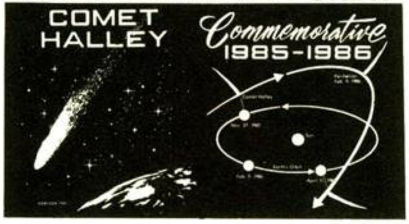
To order, use the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

Astronomy Software for the IBM PC®

Planet Positions
One minute accuracy $25
Comet Halley
Right ascension and declination plus star chart $20
Time & Date Conversions
GMT, julian date, ephemeris time, sidereal time $20
— All 3 for $45 —
Fast, bug-free programs; source listings available; optional 8087 support

Laboratory Microsystems Incorporated
Post Office Box 10430,
Marina del Rey, CA 90295
(213) 306-7412

COMET HALLEY COMMEMORATIVE T-SHIRT



"This is the definitive HALLEY COMET T-Shirt"
Beautifully designed on BOTH sides by world famous T-Shirt artist.
4-color silkscreen on highest quality 100% cotton shirts.
Choice of dark blue or black shirt; Specify: S, M, L, XL
FREE: Halley Comet Finder Chart & Calendar plus Comet History and Comet Button.
$9.95 +$1.50 shipping
Send name, address and check or M.O. to:
HORIZON PRODUCTIONS UNLTD.
158-09 Sanford Ave., Suite 1E, Queens, NY 11358
DEALER INQUIRIES WELCOME Allow 2 to 3 Weeks Delivery.

WANTED — Anyone who wants to trade NASA photos, papers, etc. Send wants and haves list to Randy Hilt, 426 N. Jackson St., Springfield, OH 45504.

FOR SALE — Renaissance refractor on JSO mount with fiberglass case (no eyepieces included). Excellent condition, $1100 or best offer. Contact David Singer, 70 Maple St., Bellingham, MA 02019. Phone (617) 966-2569 evenings.

FOR SALE — ASTRONOMY back issues, July 1976 to present with slip cases and indexes through 1979; excellent condition except for name stamped on inside. $125 plus shipping. Contact Charles Spain, 1515 S. 9th St., #306, Waco, TX 76706.

FOR SALE OR TRADE — Fujinon 14x70 binoculars, $300 or will trade for small equatorial refractor (Unitron 2.4, Pentax, etc.). Contact Gordon Jenkin, 604 W. King #12, Carson City, NV 89701. Phone (702) 885-9729.

FOR SALE — Dynamax 6 with standard accessories plus 8x50 finder, Porro prism, RFT adapter, and field tripod. Excellent condition, $700. Contact Raymond Mann, 600 Soundview Ave., Bronx, NY 10473. Phone (212) 893-5550.

FOR SALE — Celestron accessories including 26mm 1¼" Plossl, $60; 1¼" star diagonal, $25; 6x30 finderscope and mount, $35. All brand new, never used. Contact Don Hoshino, 1636 Ammon Rd., Toledo, OR 97391. Phone (503) 336-3458.

SPACE SATELLITE HANDBOOK 1986

New annual encyclopedia listing all 5,612 payloads, platforms, rockets, debris orbiting Earth, Sun, Moon. NASA, NORAD, Smithsonian data crosschecks name, country, int'l number, launch date, period, inclination, apogee, perigee, radio frequency. Handy 80-page book. **$10**

Add $1 shipping. Send cash, check, m.o., VISA/MCd. Card users send no., expiration, signature. Outside USA remit US dollars plus $2

ARCsoft Publishers
Post Office Box 132AA
Woodsboro, MD 21798

FOR SALE — *Sky & Telescope*, September, November, and December 1954. $2 each or all for $5; price includes postage. Contact Gary Peterson, 14396 30 Ave. N.E. #308, Seattle, WA 98125. Phone (206) 367-0170.

FOR SALE — Skylight filter/dust seal for C90, excellent condition, $28. F/1.65 telephoto lens with coated 80mm aperture (needs T-ring; can also function as a finder scope) including 1¼" diagonal and C8 mounting hardware; mint, $175. Contact Frank Trgovich, 3308 E. 191st St., Lansing, IL 60438. Phone (312) 474-6400.

FOR SALE — ASTRONOMY, September 1975 to December 1983; *Sky & Telescope*, April to December 1973, January 1975 to November 1976. Mint, all for $180 ppd. Contact Nicholas Marino, 2700 Fox Rd., Baldwin, NY 11510. Phone (516) 379-3117 before 10 p.m.

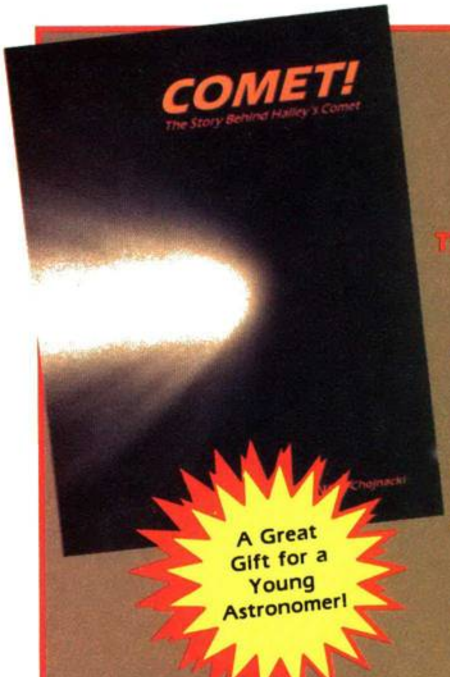
FOR SALE — 3" refractor with 550mm rich-field Unitron image erecting 1¼" star diagonal, 8x40mm finderscope, heavy-duty alt-azimuth mount with fine adjustments and extenders, and heavy duty wooden tripod. $395. Contact Ron Schulte, 61 Willis Dr., West Trenton, NJ 08628. Phone (609) 883-7864.

FOR SALE — Quantum 4 telescope with enhanced silver coatings, thread on glass solar filter, and camera adapters mounted on Celestron tripod; new condition, $1000 firm, will consider trade plus money. Also Celestron Comet Catcher, like new in original box, $200. Phone Bob at (617) 883-6775 after 6 p.m. weekdays.

Telescopes • Binoculars • Astro-Aids
Microscopes & more

BAUSCH & LOMB
4000 $484
Enchanced coatings $35
Discounts to 50%. Free Shipping
Catalogs $2.00 Tel: (203) 746-3579
Pauli's Discount Optics
29 Kingswood Rd., Danbury, CT 06811

COMETOR® 440 RFT.
4½" Aperture f/5 reflector for only $199.00.
Perfect for viewing the return of Halley's Comet.
PRECISION SOLAR FILTERS
High quality Glass & Mylar solar filters ¼ the cost of other brands. Sizes available for all telescopes up to 14" aperture. Thousands of our filters are in use around the World.
Complete technical specifications and pricing sent free upon request.
Thousand Oaks Optical
Box 314-A, Wyandotte, MI 48192
(313) 281-6929


COMET!
The Story Behind Halley's Comet
Chojnacki
A Great Gift for a Young Astronomer!

Turn a kid on to comets with

COMET!

The Story Behind Halley's Comet

by Greg Walz-Chojnacki

- Current scientific information on comets helps kids appreciate the significance of Halley's return
- Tips on observing Halley's Comet in '85 and '86
- 11 clear finder charts for northern and southern hemispheres
- 3 great projects
- Over 60 illustrations — many in full color
- 64 pages, hardcover, 8¼" X 11"

The author is associate editor of **Odyssey**, the young people's magazine of astronomy and outer space — from AstroMedia, of course!

To order, use the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

COMET!
The Story Behind Halley's Comet
$9.75

LIMITED TIME OFFER APOLLO

VIDEOCASSETTES

Official NASA Full Color-Sound Films at Giant Savings

1. Apollo 8 22 min: Borman Orbits Moon $29.95
2. Apollo 11 29 min: 1st Moon Landing $29.95
3. Apollo 15 28 min: "Rover" on Moon $29.95
4. Apollo 17 28 min: Great Earth Photos $29.95

"JANUARY SPECIAL"

Save $70.⁰⁰

All 4 films on one videocassette only $49 + $4.⁰⁰ Shipping/handling

Offer Ends February 28, 1986

VISA
Order Toll Free
800-437-0800 CA-800-437-0888
Hayes & Nolly Productions
3000 Alamo Drive, Suite 206
Vacaville, CA 95688
Unconditional 2 week money back guarantee

FOR SALE — Original complete issues of *The New York Times* final editions with full-page space headlines of historic events including Gagarin and Glenn's orbits, Gemini, Apollo, Viking, and STS-1. Like new, mint condition. $100 to $700 each, less for sequence sets (like an Apollo mission). Contact Peter A. Leavens, 44 N. Grove St., Freeport, NY 11520.

FOR SALE — C11 with coatings, solar filter, counterweight bar assembly, and many extras. Mint condition; you pick up. Contact Dante Torrese, 11 Chestnut St., Ardsley, NY 10502. Phone (914) 965-4004.

WANTED — Julius Shwaab's *Patterns in the Sky*, Gallant's *The Constellations; How They Came To Be*, and Jobes' *Outer Space*. Contact David D. Gagnon, Sargent Camp, Peterborough, NH 03458.

FOR SALE — Super Polaris C8 including 6x30 viewfinder, storage case, tripod, and four eyepieces (7mm orthoscopic, 12mm and 20mm Erfle, 18mm Kellner). Excellent condition, $800 plus shipping. Contact Tom Scott, 1206 W. 22nd, Odessa, TX 79763. Phone (915) 333-3095.

FOR SALE — 8" f/16 Cassegrain f/4 Newtonian with heavy-duty Cave mount, electric r.a. and dec., excellent optics by Star Instruments, and Novak support systems. Excellent for the Moon, planets, and astrophotography. $950. Contact Ralph Ford, 1809 Walnut Ave., Manhattan Beach, CA 90266. Phone (213) 545-1658.

HALLEY'S COMET
1985—1986

Iron-on Decals. Enhance T-shirts and lab coats! 2 decals for $2.99. Chose: **size** (3" or 5"), **color** (black or white), and **design** — ***Halley's Comet 1985-1986*** or ***1857 Cartoon.***
Send selections and payment to:
T.R. Luque (PIXEL ART), 22000 Romar St., Chatsworth, CA 91311.

METEORITES

AVAILABLE TO
ASTRONOMERS, SCHOOLS
INSTITUTIONS AND PRIVATE
COLLECTORS. STONES & IRON
SPECIMENS. **LIMITED SUPPLY,**
ROBERT A. HAAG — METEORITES
Box 27527, Tucson, AZ 85726
— *PLEASE SEND $1.00 FOR FULL COLOR CATALOG —*
Refundable on first order

JOIN NOTED ASTRONOMER

Dr. James J. Rickard

in the viewing and study of

HALLEY'S COMET

from one of the world's most advantageous celestial observation sites.

Special Escorted Tour of Chile (Santiago & Tongoy) departs New York April 9, 1986 (other departures also available). Optional extensions to Easter Island, Chilean Lake Region, Peru.

Request brochure from
JOURNEYWORLD
155 E. 55th St., New York, NY 10022
(212) 752-8308 • (800) 635-3900

TOWSON PHOTO SUPPLY

401 WASHINGTON AVENUE
TOWSON, MD. 21204
301·296·1717

CELESTRON TELESCOPES · BINOCULARS · CAMERAS

A FULL LINE DEALER SERVING THE EAST COMPETITIVELY

SEND $1. FOR CATALOGUE— refunded with your first purchase

Nikon
CELESTRON
Leitz

FOR SALE — Back issues of ASTRONOMY, October 1980 to July 1982, good condition, $20; August 1982 to September 1983, excellent condition, $20; January 1984 to July 1985, excellent condition, $30. Contact Kazys Varnelis III, POB 507, Stockbridge, MA 10262. Phone (413) 298-4943 evenings.

FOR SALE — New 10x40 finder telescope with brackets for C11 or other telescope. Never used, $70. Contact Frank Olsen, 1513 Parkwood Ln. NE, Cedar Rapids, IA 52402. Phone (319) 393-5758.

FOR SALE — Edmund Astroscan, excellent condition. Includes tripod and travel bag. Pickup preferred. Contact Bruce Smith, 3223 14th Ave. So. #9, Minneapolis, MN 55407. Phone (612) 722-5034.

HALLEY'S COMET TOUR

OF AUSTRALIA
APPROXIMATE COST $2599
APRIL 4—20, 1986
CONTACT: TRAVELROADS
1433 VAN NESS AVENUE
SAN FRANCISCO, CA. 94109

Halley's Comet is about to appear... look for the right telescope to view it with.

You can't buy a binocular or telescope before you see our latest brochure on Binoculars/Telescopes. All you do is send a stamped self addressed envelope

Leitz Nikon ZEISS CELESTRON BAUSCH & LOMB BUSHNELL Steiner

To:
ADORAMA Inc.
138 W. 34th St. N.Y., N.Y. 10001

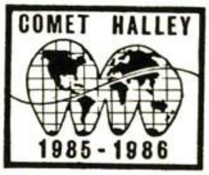
Exciting New Catalog!

Large, long-time Southwest dealer going national. Scopes, accessories, aids—huge inventory in stock. Name Brands, unique direct-import items, discount prices: 32-page illustrated catalog is a revelation (and features original Kim Poor full-color space-art covers—alone worth price). Catalog/postage/handling $2.50: refunded with first purchase. Hurry!: **SPECTRUM**
P.O. Box 32188 Phoenix, AZ 85016

LIMITED EDITION

COMET HALLEY COMMEMORATIVE COLLECTOR PIN

DESIGNED BY ARTIST J. ONGLEY
ONLY 5000 MADE
INDIVIDUALLY NUMBERED
EACH PIN CERTIFIED
PREMIUM QUALITY CLOISONNE
WHITE ON BLUE WITH GOLD



$10.00 EACH PPD. CA RES ADD 6.5%

Additional Unlimited Offerings $5.00 Ppd. CA Res Add 6.5%
A. Western Hemisphere, Blue On White With Gold Detail
B. North America, Green On White With Gold Detail
C. California, Red On White With Gold Detail
Specify Style And Quantity, Enclose Check Or Money Order

NOVA WEST COMPANY, 1613 Oakengate Dr. Glendale, CA 91207

Star Travelers

Edmund Astroscan 2001

Study stars at night, Explore nature by day
F/4.4, clear images, wide-field viewing
Rugged—easy to use
Low price
A perfect choice for getting started

Bausch & Lomb Criterion 4000

Deep space viewing in compact size and weight.
Easily adapts to super telephoto lens, focuses from 15 ft. to ∞
Bausch & Lomb quality.
A complete economical observatory system.

Specifications:

Edmund Astroscan 2001 Newtonian rich field telescope with 28 mm eyepiece (16x), with eyeguard, altazimuth mount, carrying strap, finder sight, capable of higher power magnification with additional eyepieces, and camera adaptable with optional accessory. 8.4 lbs. **$254.25***

Bausch & Lomb Criterion 4000 Observatory 4" Schmidt-Cassegrain astronomical telescope with rigid fork mount. 120 VAC electric equatorial clock drive with manual slow motion controls, 30 mm (40x) and 18mm (66x) eyepieces, 4x finder scope, adjustable latitude leg, capable of 240x with additional eyepieces, converts to 1200 mm f/11 camera lens with optional accessory. Comes contained in its own carrying case. **$519.35***

TBR/OptiSystems
12 years experience in precision optical products
P.O. Box 17129, Rochester, NY 14617,
(716) 544-2264

Gentlemen: Please send me information on:

☐ B&L/Criterion telescopes
☐ Criterion RV-6
☐ Meade Instruments
☐ Ray Ban Sunglasses
☐ Price List Only
☐ Please place my order for ______________ *
☐ Bushnell binocular
☐ Bushnell spotting scope
☐ Tele Vue eyepieces
☐ Bausch & Lomb magnifiers
☐ Dazor illuminated magnifiers

Name ______________
Address ______________
City ______________ State ______ Zip ______

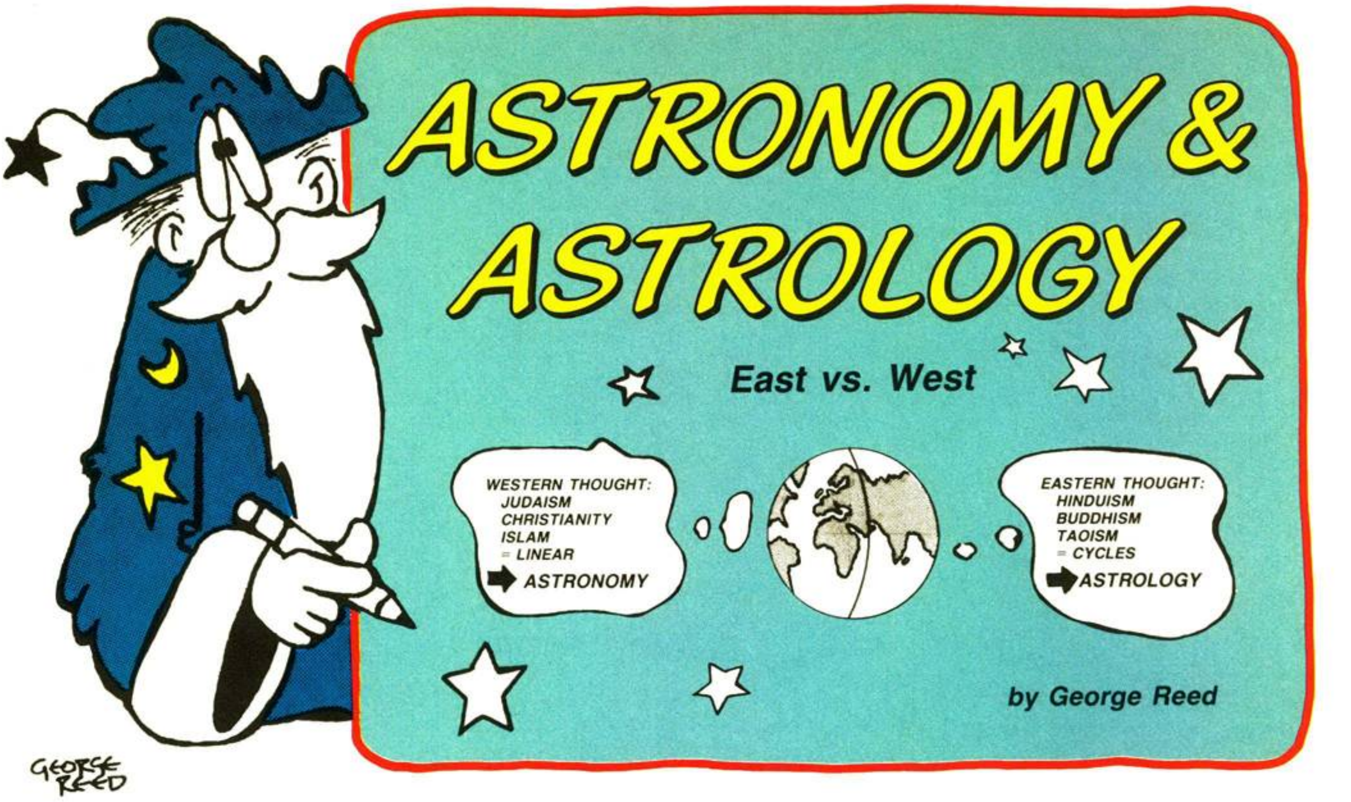
*Payment in U.S. funds only, sorry no COD's. Add $5.00 shipping & handling in the continental U.S. Write for shipping & handling charges for APO & foreign shipments. NYS residents add sales tax. Allow 4 to 6 weeks for delivery. Price subject to change without notice.

TBR/OptiSystems
850 Hudson Avenue, P.O. Box 17129
Dept. A055, Rochester, NY 14617
For fast service call (716) 544-2264
Mon.-Fr. 9:00 am to 5:00 pm ET.
MasterCard/Visa accepted.

ASTRONOMY & ASTROLOGY

East vs. West

by George Reed



The cultures of Earth's Eastern and Western Hemispheres differ greatly in their use of astronomical knowledge. Research astronomy has come to dominate the West while astrology dominates the East. How did this dichotomy come about? What does it say about the two cultures?

In his 1894 book *The Dawn of Astronomy*, English Victorian astronomer J. Normal Lockyer proposed that celestial objects are useful to societies in three distinct stages. He described the first stage as primitive wonder about the sky and worship of celestial objects. For these peoples, the sky is essentially "magical." The early histories of Eastern and Western cultures abound with evidence of objects of the day and nighttime sky tied to gods and myths that explain the existence and construction of the universe.

In the Eastern Hemisphere, the ancient Hindus saw the universe as one night's cosmic dream by Brahma. This 4,320-million-Earth-year dream began with the dance of the four-armed god Shiva, also known as the lord of the cosmic dance and the god of creation and destruction. Shiva's dance begins each new cosmic dream. When Brahma wakes, the universe ends. But after Brahma's lifetime, another sleeping and waking god will appear. (There was a similar god before Brahma.) The Hindu universe, therefore, is a series of cycles, a cosmic rhythm that extends from undetermined time-past to indefinite time-future.

The simplest Egyptian mythical explanation of the sky involved Nut, the sky goddess. Nut was envisioned as the encompassing sky with stars decorating her body. Her arched body was supported by her hands and feet above her husband Geb, the god of the Earth. At each dawn, Nut gave birth to a new Sun which moved across her body until nightfall, when it was swallowed to pass through her for rebirth the following morning. In later Egyptian mythology, the Sun was considered a god called Amon-Re, who navigated a celestial Nile in his royal barque. The summer flooding of this celestial Nile brought the Sun closer. Its reduced winter flow moved the Sun farther away. This accounted for the seasons and the varying apparent paths of the Sun across the sky.

In Western culture, the ancient Greeks saw the universe as having evolved from a disordered state of unformed matter that they called *chaos*. This confused universe was reassembled into an orderly arrangement of stars and planets — a *cosmos*, to use another Greek word. Out of that ordered array of matter came the Olympian gods. In this mythology, the gods were neither responsible for the universe nor superior to it. They were created by the universe, and the universe had but one beginning.

To all cultures, the sky looked fundamentally the same: seven naked-eye objects appeared to move through the fixed stars that formed the enclosing constellations of the night sky. These seven objects were the five naked-eye planets, the Sun, and the Moon. Because each of these appeared in the realm beyond Earth, in time they became associated with gods.

For example, the ancient Egyptians believed that each hour of the day was ruled by one of these seven naked-eye celestial objects. Even the week we use today — seven days long — was established to honor the celestial objects that ruled the first hour of each day. The order of the days in the Egyptian week stemmed from their ancient belief that the order of the cosmos followed the sequence Saturn, Jupiter, Mars, Sun, Venus, Mercury, and the Moon.

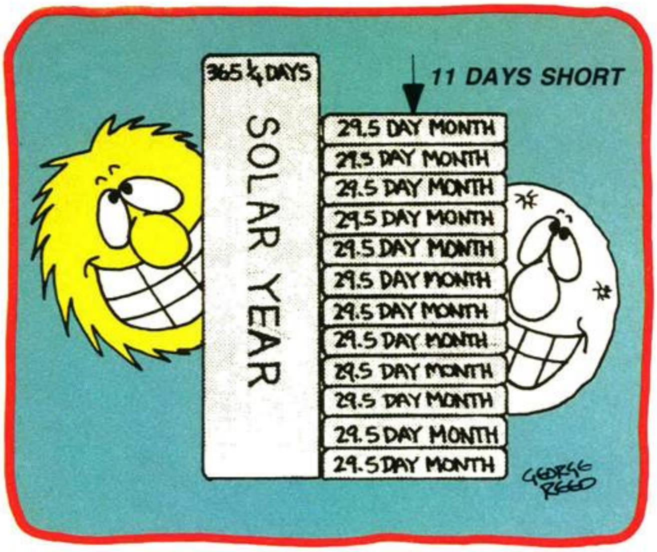
It's clear from this and many other examples that the "magic sky" satisfied a driving human need. Nor is this a thing of the past, for we still find evidence of these beliefs in many people today. Human beings want very much to have the universe understandable in human terms, and they have always projected earthly experiences into a cosmological perspective.

The second stage in Lockyer's scheme of the development of astronomy is reached when a culture uses celestial phenomena for practical ends, such as developing a calendar or navigating their ships.

The earliest calendars were based on a 29½ day period that encompassed the changing phases of the Moon. From this calendar system we derive our present unit, the "moonth." Islam and Judaism still reckon their religious year by lunar calendars.

Yet for people working the land, lunar calendars have a severe drawback — they don't fit the seasonal (solar) year very well. This spurred the Chinese to develop one of the first solar calendars. From as early as 2357 B.C., they made attempts to reform their lunar calendar into a more practical, seasonal one based upon the Sun. (This calendar reform, and the many that followed, have never been completely satisfactory because one Earth year does not contain an exact number of days.)

The form of an ancient Egyptian solar calendar passed into western civilization by way of Julius Caesar. He sought the advice



of Egyptian astronomer Sosigenes of Alexandria during the reform that changed the old Roman lunar calendar to what is now known as the Julian solar calendar. In time, the Julian calendar itself was replaced by the Gregorian calendar, established by the Catholic Church in the 16th century, which is used today in civil affairs throughout both hemispheres. The Gregorian calendar, however, still retains vestiges of its lunar ancestry in its 12-month cycle and, for Christians, in the definition of Easter as the first Sunday following the first Full Moon after the vernal equinox. Another remnant of the old Egyptian calendar may lie in our division of the day into two 12-hour segments. This most likely originated in the rising of 12 special stars during the night hours at the beginning of the ancient Egyptian year.

Easter isn't the only celebration scheduled according to celestial objects. The Chinese New Year always begins on the day of the first New Moon after the Sun enters the constellation Aquarius. And Ramadan, the Islamic month of fasting and prayer, begins with the first naked-eye sighting, by two different people, of a waxing crescent Moon following the occurrence of the ninth New Moon of the Islamic lunar year. (And you thought Easter was complicated!)

Another practical use for the sky is aligning structures with the four cardinal points or other special directions. The field of archaeoastronomy has uncovered many examples of cultures that used astronomy to align buildings and monuments. In Egypt, the pyramids and tombs of deceased pharaohs were constructed on the west bank of the Nile, the side from which their Sun god, Ra, left his people. Temples for daily worship were built on the east side of the river — the side of the Sun god's resurrection. To Pharaoh, the sky was the means of achieving immortality. The pyramid, a geometric form in the shape of rays of light descending from the life-giving Sun, made a stairway to the "imperishable" north circumpolar stars for the souls of dead pharaohs of the Old Kingdom.

The Great Pyramid of Khufu at Gizeh consists of 2.3 million limestone blocks, each weighing an average of 2.5 tons. The sides of the structure are almost perfectly square, 755 feet on a side, and align very accurately toward the cardinal directions.

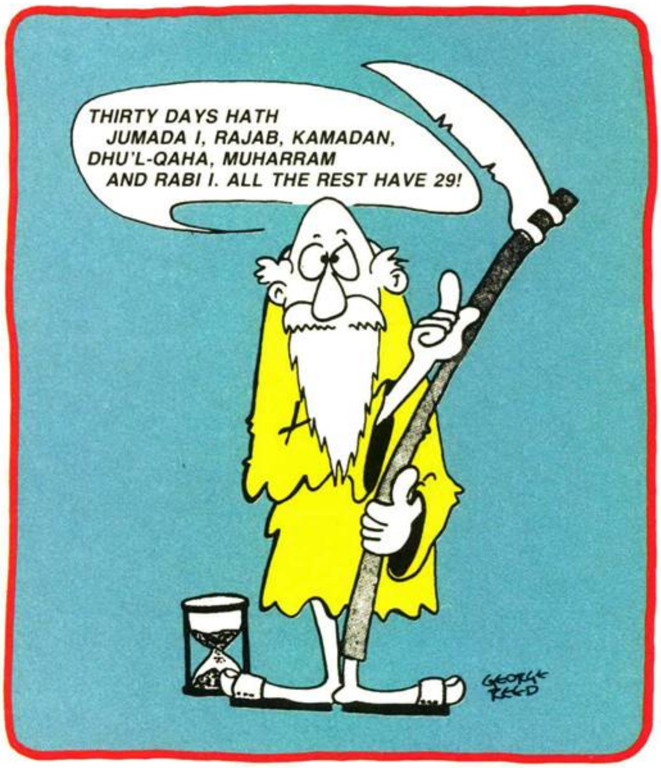
Ramses II built a celestially-aligned temple at Abu Simbel for the use of his subjects living along the upper Nile. It also served as a reminder of his power. To add the authority of the cosmos to his message, Ramses saw to it that the temple was oriented so that on two special days, light from the rising Sun shot down a 200-foot-long corridor to illuminate a statue of the pharaoh seated between two gods. These dates were February 22nd and October 22nd — his birthday and the day that probably commemorated his 30-year jubilee in 1260 B.C.

England's Stonehenge, built around 2000 B.C., has been found to be a remarkably elaborate solar and lunar calendar. The multi-ton standing stones were erected so that a person within the structure could note the dates of the solstices as well as the extreme rising and setting points of the Moon. The Heel Stone, which marks the azimuth of sunrise on the day of summer solstice, may have been an early representation of the builders' Sun god.

Chichen Itza, an abandoned Mayan city in Mexico's Yucatan jungle, features a vernal-equinox-aligned temple pyramid that was named El Castillo by the Spanish conquerors. As the Sun sets on the day of the vernal equinox, a stone serpent head at the bottom of the stairway on the north side combines with shadows from the nine terraces on the stairway's balustrade to form a spooky shadow image of a serpent undulating down the stairway. The pyramid, dedicated to Kukulcan the Feathered Serpent, has 91 steps leading up each side and one step into the temple shared by all sides. The number of steps add up to the number of days in a year.

To the ancient Khmers of Southeast Asia, astronomy was known as the sacred science. The temple of Angor Wat in Kampuchea, built with a north-south orientation around 1150 A.D., was dedicated to Vishnu, a member of the Hindu trinity that presides over the solar-related deities of the Hindu pantheon. On the equinox and solstice days, the rising Sun aligns with the major temples as seen from the western entrance to the vast temple structure.

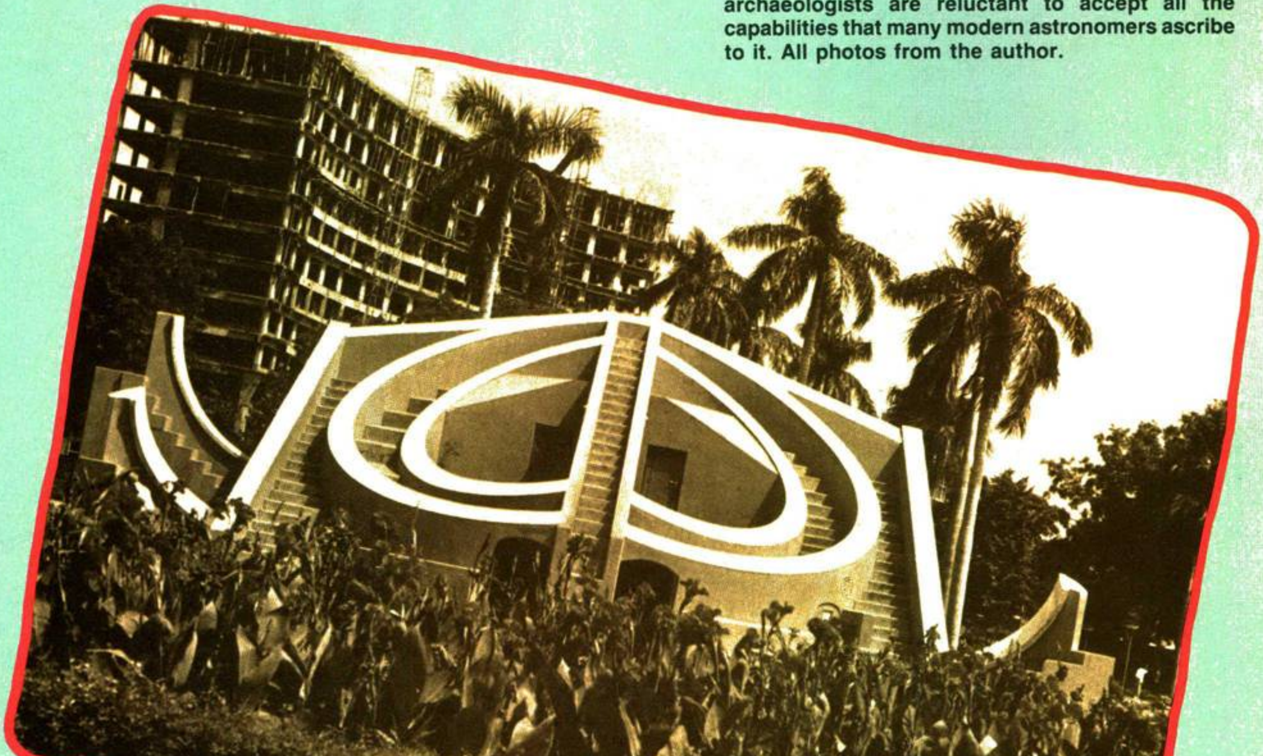
Curiously, the discovery of ancient building and monument alignments has not progressed in the East at the same rate as it has in the West. This seems primarily due to problems of access, both political and physical, and to a greater interest in archeoastronomy among European and Western researchers.


THIRTY DAYS HATH JUMADA I, RAJAB, KAMADAN, DHU'L-QAHA, MUHARRAM AND RABI I. ALL THE REST HAVE 29!
GEORGE REED

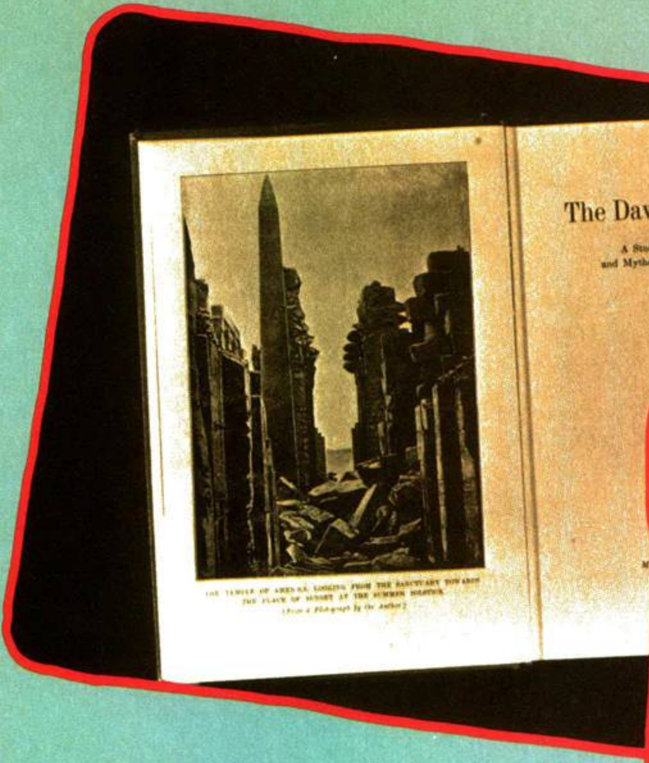
Another practical use for the sky came from the demands of trade and navigation, which gave powerful incentives to study the heavens. Much of post-Renaissance astronomy was devoted to developing tables and almanacs that would help explorers and merchants sail to new-found lands. However, until the development in the 17th century of an adequate theory for the motion of the Moon, navigation's chief problem — longitude — remained only poorly solved.

Cultures "used" astronomy in less material ways, too — one important way being astrology. Astrology is an attempt to use macrocosmic celestial objects and phenomena to predict microcosmic events. In so doing, it actively feeds the human desire to feel cosmically important. Astrology interprets the

Over a thousand years in the making, Stonehenge is evidence of the remarkable intellectual capacity of its builders. No one questions that it was used to identify the date of the summer solstice, but archaeologists are reluctant to accept all the capabilities that many modern astronomers ascribe to it. All photos from the author.



The Misra Yantra of Jai Singh, in Delhi, India, measures time, solar declination, and celestial altitudes. Built at a time when the West had been using the telescope for decades, it symbolizes the East's abandonment of "linear" science.

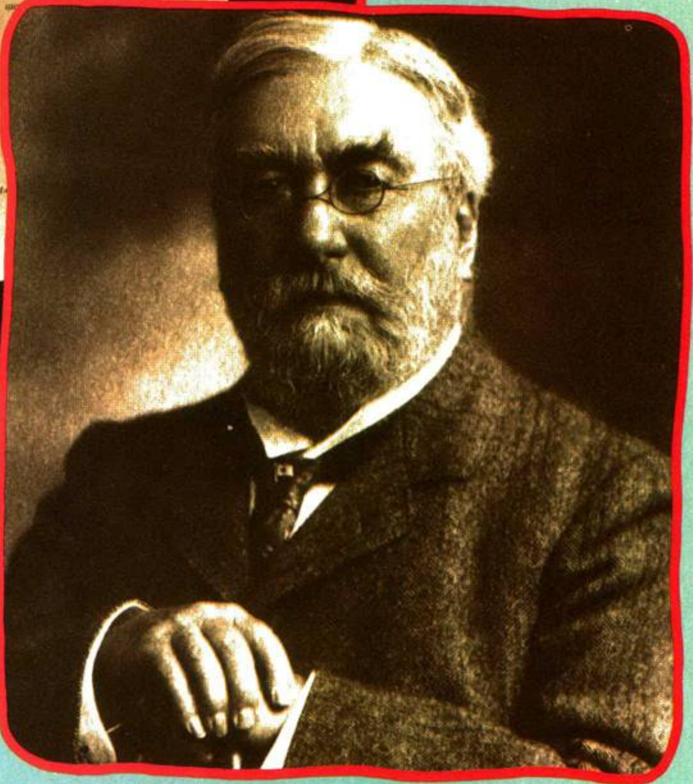


The Dawn of Astronomy

A Study of the Temple Worship
and Mythology of the Ancient Egyptians

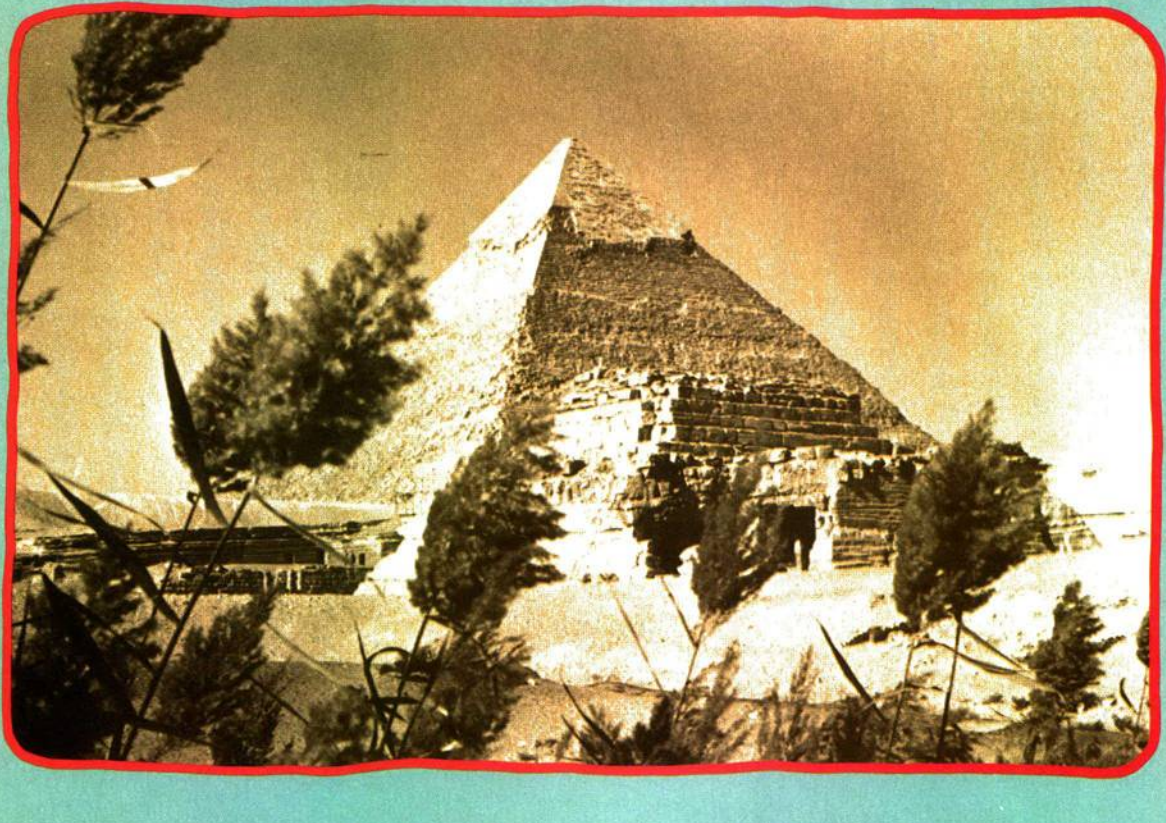
by
J. Norman Lockyer

With a Preface by



J. Norman Lockyer (1836-1920) was a solar physicist and the "founding father" of archaeoastronomy. The discoverer of helium in the solar chromosphere, Lockyer also spent many years studying ancient monuments and buildings seeking astronomically significant alignments in their structures as clues to the "dawn of astronomy."

Though much nonsense has been written about pyramids, it is clear that their sides were aligned to face the cardinal directions as accurately as their builders were able. Whether designed as stairsteps for Pharaoh to ascend into heaven or simply as stone effigies of the Sun god's rays, pyramids stand as giant monuments to mankind's fascination with the "magical" sky.



relationship between man and the universe, placing special emphasis on the celestial events occurring along the zodiac. Because astrology concerns itself with making connections between events in the cosmos and an individual's consciousness, it does not deal with cause and effect but rather with the possibility that events may occur in certain places at certain times. *Astra inclinant, non necessitant* — the planets incline, they do not determine.

Astrology began in ancient Babylonia as a state concern that dealt with national and worldwide events. Given that its practitioners needed at least some celestial observations, Babylonian state astrology also incorporated state astronomy. The two fields remained tightly interwoven until the time of the Greeks, who systematically began seeking direct and observable causes for events. But the differences between the two were more implicit than overt, for Greek culture retained a strong belief in astrology and extended its forecasts to individuals. The Greeks developed an astrology that inferred the personality characteristics of an individual by the placement of the sky at the time of birth. The Greeks also believed that astrology could create horoscopes for day-to-day guidance and advice.

Astrology also presupposes a correlation between the Moon and terrestrial events, a belief that has become deeply imbedded in folklore and superstition. In many rural areas today, farming activities that concern "increases" (such as planting peas or corn) are performed during the waxing Moon, and activities designed for "decreases" (such as planting carrots and onions) are performed during the waning Moon.

Two centuries ago, English law drew a distinction between people who were chronically insane and "lunaticks" whose behavior became strange only around the time of Full Moon. Lycanthropy, the ability of the Full Moon to transform a human into a werewolf or some other feared animal, is not just a product of Hollywood movies — it is a worldwide folk belief.

Comets have long been thought to be celestial heralds of misfortune. In 1456, Halley's Comet appeared in the sky at the same time that the Turks invaded Europe. Pope Calixtus III's response was to order the faithful to recite a prayer every noon: "God save us from the Devil, the Turk, and the Comet." And to ensure that God was paying attention, the pope commanded all church bells to be rung at noon. The plan was so successful that church bells and firehouse whistles *still* sound out at noon in many communities.

Even the belief that the Star of Bethlehem was an actual star is an attempt, perhaps unconscious, to validate the claim that celestial events foretell terrestrial events. Modern astronomy has no clear, unambiguous explanation for this "star" that led the Wise Men (almost certainly Zorastrian astrologers) to the manger in Bethlehem. One is forced to admit that either the event was just a literary device used by Matthew to enhance his story, or that it was a temporary suspension of physical law — in short, a miracle.

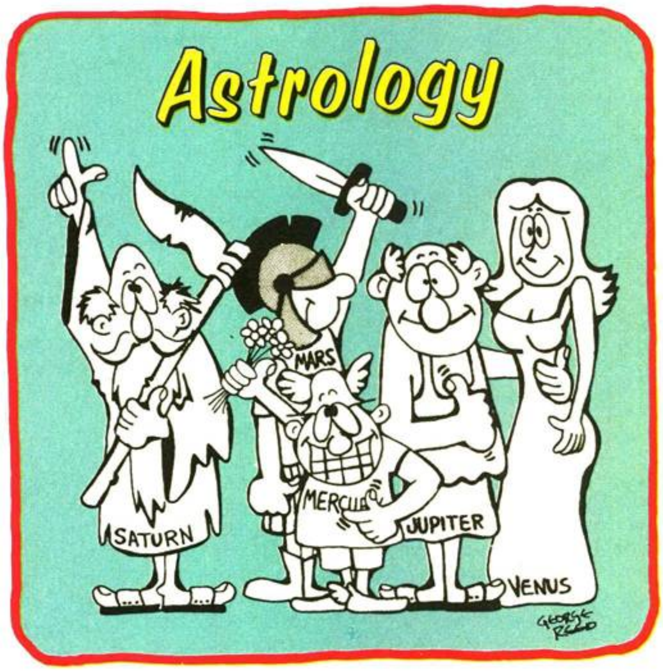
While astrology is found throughout the world today, it dominates many Eastern cultures such as India's where it is a routine part of life. Newspaper advertisements for arranged marriages require the exchange of horoscopes. Marriages thus deemed lucky are then scheduled for astrologically auspicious times. First birthdays are not celebrated on the birth anniversaries, but on favorable days determined by astrologers. Even filming a movie doesn't begin until an astrologer determines the right time for a major scene to be filmed.

In the early 17th century, something very important happened in the West and, as a result, astronomy began to diverge in earnest from astrology. That "something" was the invention of the telescope.

When this happened, Western astronomy entered upon the third and last stage proposed by Norman Lockyer. Henceforth, astronomy's main purpose was to observe celestial objects for the advancement of knowledge. Astronomy became research oriented, and although it continues to have some practical uses today, astronomy's role in everyday life largely ended by 1700. Haltingly at first, astronomy came to be supported in the West by governments, educational institutions, and private sources; it no longer had to sell its services through astrology to survive.

With the invention of the telescope, astronomy's growth picked up speed. Galileo Galilei was the first to scan what had been a naked-eye universe with the added power of the telescope. He discovered the first four satellites of Jupiter, the starry construction of the Milky Way band across the night sky, and the mountains of the Moon. He observed the phases of Venus, and from his observations of sunspots deduced that the Sun was rotating.

Johannes Kepler, Galileo's contemporary, used precise observations of Mars to discover that celestial bodies follow elliptical paths. He also produced the first mathematical statements describing the motions of celestial objects. Isaac Newton, late in the 17th century, produced a magnificent synthesis of the observed universe with his mathematical theory of universal gravitation.



Edmond Halley used Newton's laws to predict the return of a spectacular comet with a period of 76 years. He hoped that "candid posterity will not refuse to acknowledge that this was first discovered by an Englishman," which indeed it hasn't.

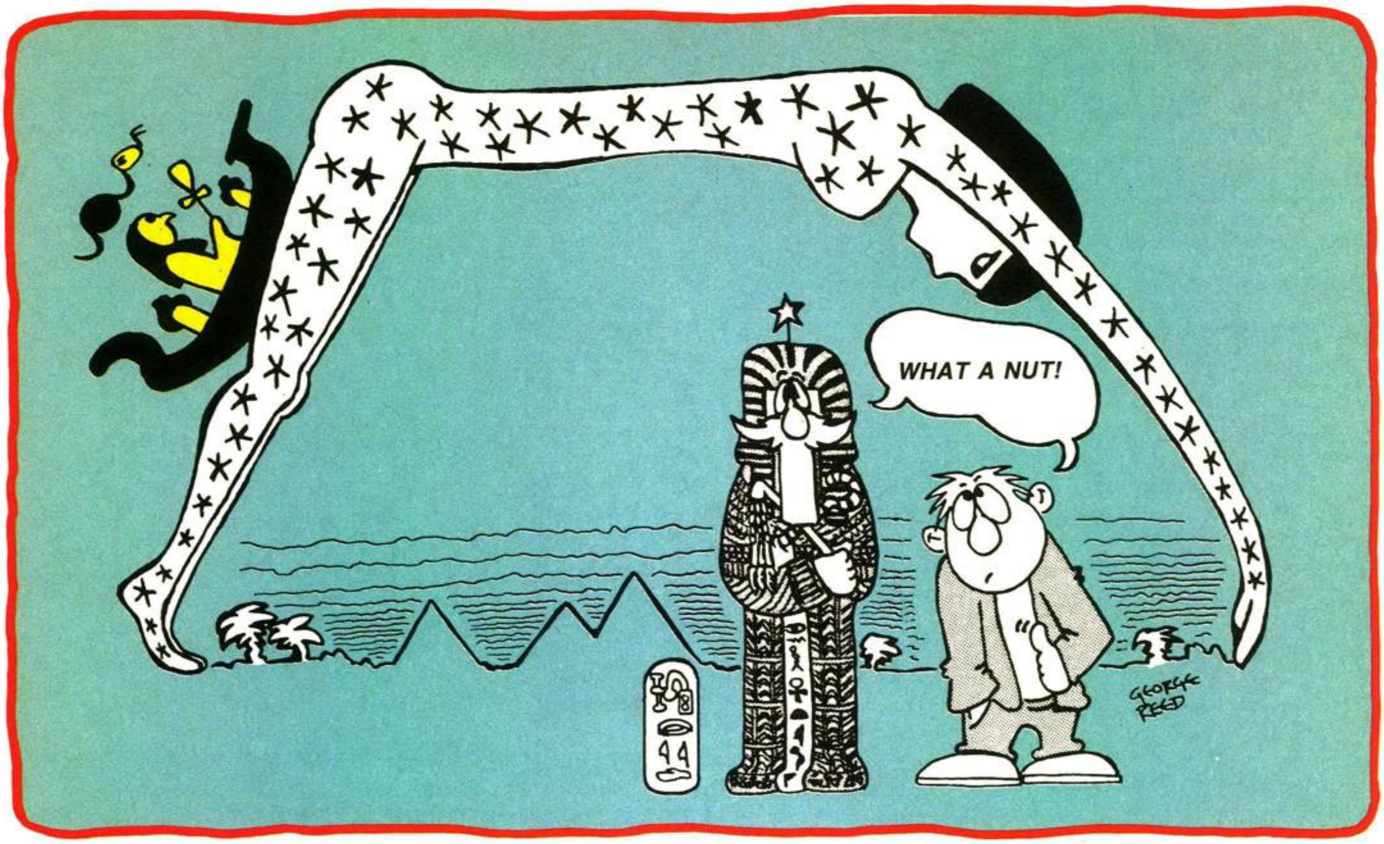
But the East did not follow suit. At the time when Western astronomy was establishing physics as a science and building telescopes of steadily-increasing size and quality, Maharajah Jai Singh was chiefly concerned with building a large series of sundials (see "The Observatories of Jai Singh," ASTRONOMY, January 1985) on his estates in India. Western astronomers were invited to China, but only to help the isolationist Chinese with their continuing need for calendar reform. The East chose not to pursue telescopic astronomy and thus missed out on observing for the sake of knowledge.

In 1781, William Herschel's telescope revealed Uranus, the first planet discovered since prehistoric times. Herschel went on to observe and catalog the visible universe with giant reflecting telescopes of his own design and construction.

By the time that Albert Einstein introduced his General Theory of Relativity in 1915, claiming that space is curved and that gravity results from the curvature of space, astronomy had become astrophysics. It was now seeking to devise detailed physical models for an increasingly bizarre array of celestial objects.

In 1931, Edwin Hubble determined that the distance to M-31, the Andromeda *Galaxy, was one million* light-years. Our Milky Way Galaxy became just one small part of a universe filled with galaxies.

Arno Penzias and Robert Wilson in 1965 discovered the 2.7



Kelvin primordial background radiation, a relic from the Big Bang creation of the universe 16 to 20 billion years ago.

Is modern astronomy then purely a product of Western astronomers? The contribution of Meghnad Saha's ionization theory to an understanding of stellar spectra and of Subrahmanyan Chandrasekhar's research into the evolutionary paths of old stars seem to say no. Western astronomy is not so much a possession of westerners as it is an approach to the universe. Although Saha and Chandrasekhar were born in the East, they worked in Western environments. Saha was at the University of Calcutta in British-dominated India and first announced his ionization theory in a British scientific journal. Chandrasekhar did his astrophysical research at the University of Chicago. In fact, these two scientists simply point out the conspicuous lack of Eastern astronomers in the past two or three centuries.

So why did the Eastern Hemisphere fail to progress significantly beyond astrology? What kept it from pursuing what we call "modern astronomy"? The best answer may be that astrology, the erring wayward parent, fully satisfied the East's religious and philosophical thinking.

Eastern religious and philosophical schools can be characterized as animistic in their world view. They ask "why" questions and seek a designing intelligence beyond the facade of sense perception. They look for explanations of the universe in terms of underlying intentions and purposes. Eastern religious and philosophical thought seeks spiritual escape from a confining dependence on the body and the physical world and therefore has little interest in comprehending what it is trying to escape.

The East stopped at astrology because it provided a comfortable scheme for the universe: astrology deals with cycles and portrays the believer as a necessary interactant, an integral component of a cyclical, purposeful, animistic universe. Hinduism, with its emphasis on karma and dharma, is more attuned to astrology than astronomy. Karma, the belief that actions in the present affect future existences as an eternal soul journeys through a cycle of births, deaths, and reincarnations, is only an extension of the recurring cycles of the celestial domain. And dharma, carrying out one's duty in life as dictated by social background and custom, is where an individual fulfills the destiny set by the celestial domain at birth. The individuality of the believer in Eastern thought is suppressed and made a part of the universe.

On the other hand, Western religions and philosophical schools can be characterized as mechanistic in their world view. They ask "how" questions and seek precise, mathematical relationships between sense perceptions. They approach the universe in terms of physical cause and effect.

The major religions of the Western Hemisphere are not cyclical, like those of the East, but linear. Judaism, Christianity, and Islam start with an event and proceed toward a promised end. In Western religions, the individuality of the believer is paramount. The universe is a stage on which to achieve *individual* salvation — and believers receive but one curtain call.

The pursuit of pure astronomy, like Western religions and philosophies, is a linear activity. The Western astronomer studies the universe as an outsider and works toward knowing the universe in much the same way as a religious believer studies sacred literature to know religious truth. Even astronomy's best model for the universe is linear. It began some 15 billion years ago with the Big Bang and is proceeding toward a cold, motionless end.

The advance from astrology to astronomy in the West reflects a major dichotomy in human thinking: away from an inward-looking, "meaningful" cosmos toward an outward-gazing, impersonal one. That shift, however caused, has had enormous repercussions in every aspect of human life. By now there is no place on the planet wholly unaffected by Western culture.

And yet we are still left with unanswerables: What compels a culture to embrace the analytical over the intuitive? Is astronomy — or all of modern science in fact — simply a by-product of the linear thinking that Western religions foster?

George Reed teaches astronomy at West Chester University in West Chester, Pennsylvania. He is the author of The Astronomy of One Constellation, Naked-i Astronomy, *and a forthcoming work of historical fiction titled* Murdered by Isaac Newton.

focus

FREE Professional Optical Maintenance Kit & "Astrophotography Basics" by Kodak ($18 Value) With Purchase

ENJOY ASTRONOMY AT DOWN-TO-EARTH PRICES

FOCUS CAMERA INC.
4421 - 13th Ave. Dept. 11AS
Brooklyn, N.Y. 11219

For Orders Only,
CALL TOLL FREE **800-221-0828**
For Information & Sales; Also Alaska, NY & HI, 718-436-6262
Ask for Bob, Harvey or Mark, our Telescope Experts

FOCUS CAMERA & ELECTRONICS has been serving customers nationwide with all their photographic needs for over 16 years, with a solid reputation for integrity. We invite you to join our hundreds of thousands of satisfied customers. Give our knowledgeable sales staff a call TODAY! **AND SAVE!!** **SATISFACTION GUARANTEE:** Refund or Exchange within 14 days (less shipping) if Returned in original MINT CONDITION with all papers intact **Customer Service 718-871-7608**

ASTROPHOTOGRAPHY OUTFIT

- **Criterion 4000 1200MM Telephoto Lens**
- Deluxe Slik Tripod
- Cable Release
- Camera Adapter
- 4-Piece Cleaning Kit
- Solar Filter Action Guide
- Deluxe Carrying Case
- **Your Favorite 35mm Camera, From the List Below:**

Outfit with Minolta X-700	**544.90**
Outfit with Nikon FG Programmable	**524.90**
Outfit with Pentax ME Super + $25 Cash Rebate	**514.90**
Outfit with Olympus OM-PC	**504.90**
Outfit with Canon T-50 Motorized	**489.90**

CELESTRON PRECISION OPTICS

LIMITED LIFETIME WARRANTY

WORLD'S FAVORITE SUPER C8 PLUS

- 8" Aperture • 480 Power
- Gathers 791 times more light than the eye
- Ultra precise gear drive

Ask About "Starbright Coating"

Complete outfit w/Oculars, Finderscope etc. as supplied by the manufacturer. **1349** With **Wedge & Adjustable Tripod**

8" Optical Tube Assembly, *Big Brother* **629**
Photo Tripod ..... **89.90** Solar Filter 8" **239**

SUPER POLARIS C8

w/Super Polaris Equatorial Mount & Adjustable Tripod ..... **CALL**

Super Polaris C8 w/*Special Coating*, #11028	**959**
SP-C8*, w/Starbright Coating for Maximum Light Transmission	**Limited Quantity In Stock**
COMET CATCHER by Celestron	**273**
Comet Catcher Jr.	**210**
Sky Sensor Computing Control	**349**
SP-C102 w/Super Polaris Mount 38X, Dew Cap, Black	**890**

C90 SPOTTING SCOPE 7-PC OUTFIT **$349⁸⁰**

- C90 Scope
- 30mm Ocular
- 18mm Ocular
- Finderscope
- Star Diagonal
- Lens Cap
- Carry Case
- Hi-Tech BLACK

C6 NEWTONIAN w/Eqtrl Mount, Slow Motion Finderscope, Ocular & Tripod **CALL**
C-130 5" Newtonian w/Tripod **$549**
RICH FIELD LENS 1¼", Will Capture 20% More Field-of-View & Will Give 20% Brighter Image w/Any 1¼" Telescope **28.90**

CELESTRON COMETRON SALE

COMETRON 60 w/2 Oculars, Adjustable Tripod, Lens Hood & Finderscope	**159**
CO-114 REFLECTOR 4.5" Scope on Eqtrl Mount w/Adjustable Tripod	**349**
ZOOM REFRACTOR 20 to 60 Power w/Eyepiece & Tripod #31020	**179**
SUPER POLARIS C80 w/Tripod	**609**
COMETRON 50 BRASS w/Pedestal	**279**

SS-50 **Celestron Spotting Scope w/20X Eyepiece, Hi-Tech Black** **129**
C65 Spotting Scope ..... **124** Deluxe Zoom Ocular **76**

Authorized Meade Dealer

A WHOLE LOT MORE THAN MEETS THE EYE!

LIFETIME WARRANTY

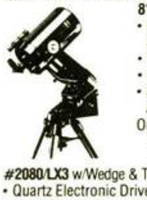
THE IDEAL SPOTTING SCOPE FOR VIEWING HALLEY'S COMET **CALL**

MEADE **97D w/5X24 Viewfinder**
- 1000mm Effective Focal Length
- 49X More Brightness than the Human-Eye
- 40X & 83X Eyepieces Included

#107D (40X & 111X), 1000MM Effect **417**

INTRODUCING THE FAMOUS SCHMIDT-CASSEGRAINS from MEADE

Authorized Meade Dealer



8" MODEL 2080LX2
- Best Seller Astronomical Telescope for the Serious Amateur
- Tremendous Light Gathering Capacity
- Hi-Transmission Coating
- *Supplied w/Ultra-Precise Drive System to Automatically Track Astronomical Objects*

Outfit includes Star Diagonal, 2 Eyepieces 100X & 286X & 8x50 Finderscope **1189**

#2080/LX3 w/Wedge & Tripod • Top-of-the-Line: The Ultimate in 8"
- Quartz Electronic Drive System
- Multi-Coated Diagonal Prism ..... **CALL**

2080/LX3 With **Multi-Coated Silver Optics**	**IN STOCK!**
#2080 8" Telescope w/High Transmission	**998**
REFRACTORS #295 2.4" Equatorial, 900MM, 100X	**329**
#320 3.1", 900MM F11, 1¼" O.D., w/Tripod	**499**
COMET SEEKER 2.4" Wide Field, w/Tripod & Carry Case	**239.90**
6600, 6" Reflector (30X & 85X) w/Tripod	**639**
8800, 8" Reflector (37X & 102X) w/Tripod	**829**

ZEISS THE MOST PRESTIGIOUS!

		6x20B Indiv. Focus (IF)	**153**
		8x20B Center Focus (CF)	**174**
8x20/IF	**162**	10x25B/CF	**197**
8x30B/CF T*	**363**	10x40B/CF T*	**437**

RUBBER ARMORED:

7x42B/CF/GA T*	**399**	7x50B/IF/GA T*	**498**
8x30B/IF/GA	**299**	8x30B/CF/GA T*	**372**
8x56B/CF/GA T*	**499**	10x40B/CF/GA T*	**441**
15x60CF/GA T* Porro Binocular			**739**
30x60B/GA T* Spotting Scope			**564**

Nikon **SPOTTING SCOPES & BINOCULARS**
The Famous Nikon Optics Are Your Best Assurance For Clear And Crisp Images

NIKON SPOTTING SCOPE	**198**
Photo Attachment	**126**
3.5X Sports Glass	**38.90**
9x25-CF Compact	**49**
7x35-E High Eyepoint	**109**
10x35-E High Eyepoint	**128**
7x50 Standard High Performance	**163**
10x50-CF Delux	**119**

10x70-IF ..... **288** 12x40 ..... **174** 7x20-CF **44**
8x20 Roof Prism ..... **112** 8x30D Rubber **159**

CELESTRON PRECISION OPTICS

GIANT BINOCULARS

- Perfect for Astron omy & Low Light Viewing
- Glare-Free Viewing & No Eyestrain
- Exceptional Image Quality
- 25 Year Warranty

11x80	**218**
20x80	**228**
30x80	**238**
10x70 Astro Observation	**309***
Deluxe 20x80	**358**

BUSHNELL division of BAUSCH & LOMB

SPACEMASTER 45° KIT:
- SPACEMASTER 45°
- 60X Hi-Mag Eyepiece
- Table Tripod
- Fitted Case **239**

SPACEMASTER 4-PC. OUTFIT:
- SPACEMASTER 60MM
- 15-60X Zoom Eyepiece
- Mini Tripod
- Attaché Case **219.90**

DISCOVERER

Spotting Scope w/15X-60X Zoom	**186**
Camera Mount	**24**
Case	**19**
Car Window Mount	**35**

TROPHY 12X-36X Zoom Armored w/Tripod **199.90**
STALKER 10-30X Zoom w/Tripod **123.90**

THE CRITERION 4000 OBSERVATORY TELESCOPE

BUY SOMETHING WORTH LOOKING INTO!

- Compact 7"x7"x14" weighs 10 lbs.
- Includes Finderscope, 2 Oculars & Adjustable Legs
- 1200mm Effective Focal Length
- With Electrical Clock Drive

9-Piece Outfit **449.90**
Criterion 6000 Telescope Complete Kit **749.90**
Criterion 8000 Telescope Complete Kit ..... **CALL**
Bausch & Lomb 4000 Spotting Scope **309.90**
Porro Prism ..... **38** 2X Barlow **31**
Nebula Filter ..... **71** Camera Adapter **28**

COMET SEEKER
9x-30x Zoom Sportview
#78-1938

FOCUS SPECIAL! $59⁹⁰ 1 Per Customer

BUSHNELL division of BAUSCH & LOMB

8-24x50 Zoom Instafocus	**118**
8x24 Fog-Proof CF	**178**
7x35 Wide Explorer	**96**
7-15x35 Zoom	**75**
7x35 Wide Sportsview	**39**
7x35 Extra Wide	**48**
7x35 Ensign **SPECIAL!**	**27**

LEITZ TRINOVID

- The Singular Choice of Those Who Demand the Absolute Best
- Perfect for Eyeglass Wearers
- Conditional Lifetime Guarantee
- Climate, Dust, Spray–Waterproof
- Armoured Models are Resistant To Impact and Shock

Leica **FEATURING THE EXCLUSIVE 2 YR. PASSPORT WARRANTY PROTECTION. UNCONDITIONAL GUARANTEE**

7x42BA ..... **348*** 8x32B **352***
10x40B or 10x40BA ..... **50 Rebate**
7x42B or BA, 8x40B or BA ..... **50 Rebate**
8x20BC/BCA or 10x25BC/BCA ..... **25 Rebate**
Call For Lowest Prices *Includes 50 Rebate

UNITRON

EXCELLENCE BY DESIGN
SINCE 1952

"For An Astronomical Deal... Take A Closer Look At UNITRON"!

#1 TOP SELLER!

NEW PRODUCT

INTRODUCING:
HALLEY'S KOMET SPOTTER
- 12X-40X Power Zoom
- Roof Prism, Right Side Up Image
- 5 Element Coated Lens
- Built-in Star Coordinate Compass
- w/24' Tripod & Eye Guard
- w/Field Carry Case **$124⁹⁰**

#404A 30x40 ELEGANT BRASS ANTIQUE TELESCOPE w/Brass Table Top Tripod **$149.90**

CELESTRON PRECISION OPTICS

HALLEY'S COMET ANNIVERSARY KIT A

- Celestron **Zoom Master** 12-60X Power Rubber Coated **Spotting Scope** w/Tripod Adapter, In Gift Box
- **Photographic Tripod**
- Celestron **Sky Maps**
- Halley **Comet Finder** Book
- Giant **Halley Poster**

LIMITED AVAILABILITY
($650–Celestron Retail)

5-PIECE OUTFIT VERY SPECIAL AT 289⁹⁰

CELESTRON PRECISION OPTICS

HALLEY'S COMET ANNIVERSARY KIT B

- Cometron **Comet Catcher Jr.**, 100 0MM 5" Table Top Reflector With 25MM 1¼" Ocular
- **Table Top Tripod**
- Halley **Comet Finder** Book
- Giant **Halley Poster**
- **Celestron Sky Maps**

Only 15 Sets;
First-Come First-Served

($550 Celestron Retail)
VERY SPECIAL AT 287⁹⁰

CELESTRON PRECISION OPTICS

HALLEY'S COMET ANNIVERSARY KIT C

- **Cometron 60 Telescope** With 32X (25MM) & 89X (10MM) Magnification
- **Adjustable Tripod**
- **Dew Cap**
- 6x24 **Finderscope**
- Celestron **Sky Maps**
- Halley **Comet Finder** Book
- Giant **Halley Poster**

($350 Celestron Retail)
Only 15 Sets Available

7-PIECE OUTFIT VERY SPECIAL AT 209⁹⁰

Meade

HALLEY'S COMET ANNIVERSARY KIT #1

- MEADE **8800 8" F4.5 Reflector** With Full Equatorial Mount, Slow Motion Controls, 9MM & 25MM Oculars (102X Magnification) & Finder
- Full Length **Tripod** • **Sky Maps**
- **Camera Adapter** 1¼"
- **Astrophotography Basics** & Eclipses

($1490 MEADE Retail)

5-PIECE OUTFIT VERY SPECIAL AT 839⁹⁰

Meade

HALLEY'S COMET ANNIVERSARY KIT #2

- MEADE **4" Schmidt-Cassegrain 1000MM F10** w/Viewfinder, 2 Eyepieces (111X Magnification) and Finderscope
- Dew Cap/Shade • **Camera Adapter** .96"
- Full Length **Tripod**
- **Astrophotography Basics** & Eclipses
- **Sky Maps**

Only 12 Sets Available
(MEADE RETAIL $900)

6-PIECE OUTFIT VERY SPECIAL AT 477⁹⁰

UNIQUE "DEEP SPACE" SERIES TELESCOPES from MEADE

DS-10A 10" f4.5 Ultra-Sharp Reflecting Telescope w/Motor Drive, Setting Circles and Deluxe Focuser ..... **IN STOCK**
DS-16A 16" Reflector. Gathers 4 Times as Much Light as an 8" Scope! Includes Motor Drive, Focuser & 1¼" Eyepiece ..... **CALL**

SWIFT **SPOTTING SCOPES & BINOCULARS PAR EXCELLENCE** SAVE

SPOTTING SCOPES:

#840 Lynx 20-60x65 Spotting Scope	**448.90**
#841 Telemaster 15-60x60 Spotting Scope	**229.90**
#844 20x60 Armoured Commande Spot. Scope	**159.90**

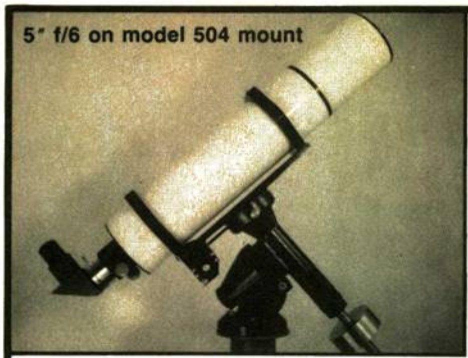
Swift Tripod ..... **$64.00** Attache Case **39.00**
Tubular Case ..... **$19.00** Camera Adapter **18.00**

focus CAMERA

4421 -13th Ave.
Brooklyn, N.Y. 11219
ORDERS: 800-221-0828
INFORMATION: 718-436-6262
CUST. SERVICE: 718-871-7608
Check Our Reasonable Shipping Rates

Orders shipped promptly—Mastercard, Visa gladly accepted. You may use your American Express card. No surcharge on Visa/Mastercard. Please add estimated charge for shipping, handling & insurance. Written inquiries welcome. Not responsible for typographical errors. HOURS: Mon-Thurs 10-7/Fri 10-3/Sun 10-6. All merchandise avail. at prices shown while supplies last.
All Telescopes Include Full U.S.A. Warranty.

CATALOGUE
Our New 96 Page Catalogue Featuring the Latest in Photographics & Electronics **$3**



5″ f/6 on model 504 mount

Astro - Physics HIGH RESOLUTION REFRACTORS

4 Inch f/6 APOCHROMAT — An ideal Astro-camera/RFT that can also be used at very high powers with no annoying color. Field coverage is 3.2° on 35mm format at f/6, 4.8° with f/4 telecompressor.

4″ f/6 Tube Assy., giant focuser, coated optics. $795

5 Inch f/6 APOCHROMAT — Similar to our 4″, the light grasp of this powerful instrument approaches that of an 8″ mirror scope. Contrast and image quality are superb! 35mm coverage is 2.6° at f/6, 4° at f/4.

5″ f/6 Tube Assy., giant focuser, coated optics. $995

6 Inch f/8 APOCHROMAT — This powerful instrument features an elegant new optical design at a very affordable price. Take this Refractor to any star party and watch people's eyes light up when they see crisp planetary detail at 600X. Try that with any commercial telescope! The high performance of this instrument is due to very tightly controlled optical tolerances. Photographic images are less than 25 microns over a 1.6° field (2.4° with f/5.3 telecompressor). Optional Barlow Amplifier is available for high power Lunar/Planetary observation at f/16.

6″ f/8 Tube Assy., giant focuser, coated optics. $1295

MODEL 706 German Equatorial

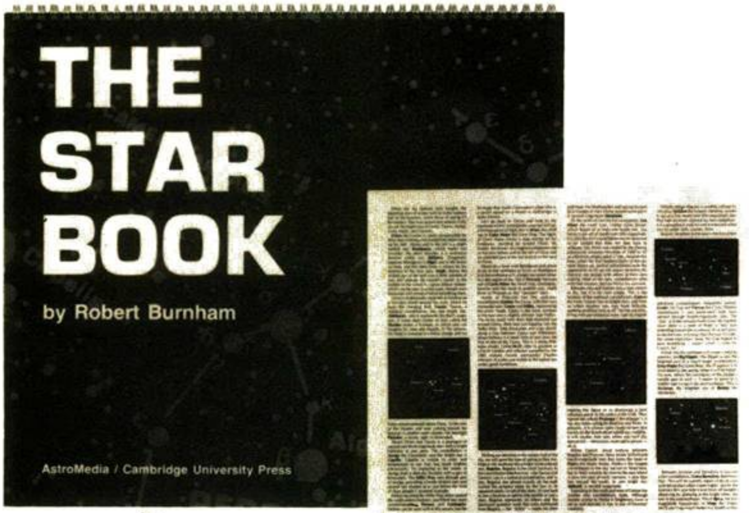
Precision German Equatorials — These rugged mountings are perfect companions to our refractors. Made of virgin sand cast aluminum, they feature stainless steel shafts, large thrust bearings, and precision BRONZE worm drives.

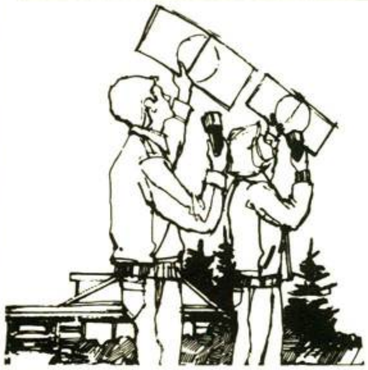
Model 504 mount for scopes up to 20 lb.	$795
Model 706 mount for scopes up to 30 lb.	$995

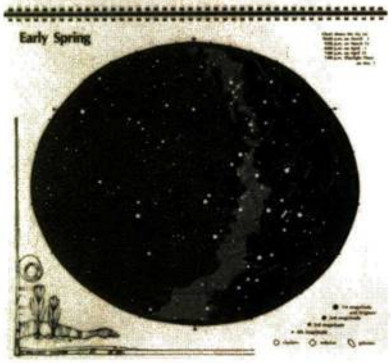
Our optics are 100% AMERICAN MADE, hand corrected to 1/20 wave pk. (1/56 wave RMS). For more information about these products and their matching accessories, WRITE:

Astro - Physics

839 Brae Burn Lane
Rockford, Illinois 61107







Learn the Constellations with

THE STAR BOOK

Now in its second big printing, THE STAR BOOK is the surefire way for anyone to learn the constellations. 8 charts cover all seasons and each map is accompanied by a description of the stars, the constellations, and their lore and legends written by ASTRONOMY's Robert Burnham.

- all northern constellations shown
- identifies galaxies, nebulae, clusters and major stars
- easy to use at night
- printed in two colors on thick cardstock
- coated with a water-resistant varnish
- heavy-duty wire binding
- folds back for your convenience
- will give years and years of service

THE STAR BOOK 10″ x 11¼″

$6.95

To order, use the ASTRONOMY order form bound into this magazine, or send to: ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

New York Camera

For Visa or MasterCard Order
Dial Toll Free (Orders Only)
800-223-6119

Meade

THE LEADER'S EDGE

*Lifetime Warranty

SPECIAL
Up to 40% Off
All Accessories

8" MODEL 2080/LX3*
Schmidt-Cassegrain Telescope complete with all accessories as supplied by the manufacturer. Including Quartz Electronic LX Drive System with field tripod & wedge. Operates AC or DC................ **1550**

10" Model 2120/LX3*...**CALL** 8" Model 2080*...**CALL**
8" Model 2080/LX2* ....**CALL**
2080/LX3 w/multi-coated/silvered optics group .....**CALL**
4" Model 2045 Schmidt-Cassegrain* ....**CALL**
6" Newtonian Reflector Model 6600 with German Equat Mt 900mm f5 with USA made PYREX OPTICS **659**
8" Newtonian Reflector Model 8800 ....**859**
DS10A w/Motor Drive and Pier ....**IN STOCK**

TELEPHOTO LENSES		**SPOTTING SCOPES**	
90B 1000mm f11	**298**	97D 3.5"	**329**
102 1000mm f10	**CALL**	107D 4"	**429**

Refracting Telescopes
Model 226 2.4" Complete w/Tripod **139**
NEW 320 80mm equatorial w/Tripod .... **IN STOCK**

BAUSCH & LOMB-CRITERION .... **CALL**

UNITRON Equatorial Refractors

Model 128 2.4" Equatorial Refractor with 1¼" eyepieces & tripod .. **495.**

Model #142	**3"**	Model #131C	**3"**	Model #152	**4"**
Model #510	**5"**	6" Custom Made		**Call for Low Prices**	

All complete w/tripod, eye piece accessories & 25 yr. warranty.

CELESTRON

PRECISION OPTICS Lifetime Warranty

SUPER C8 PLUS*
Schmidt-Cassegrain Telescope Complete with all Accessories as supplied by the Manufacturer including 7" Byers Worm Gear Drive **1099.00**

Special Outfit including Celestron Adjustable Tripod and C5/8 Wedge ....**CALL**
Super Polaris C8 Telescope w/Tripod **785**
Super Polaris 8" Newtonian.............. **IN STOCK**
Sky Sensor Computer with Quartz Motors **380**
SPECIAL COATING CALL STARBRIGHT COATING CALL
C90 Astro Telescope* With Electric Clock Dr...... **CALL**
C6 Newtonian ....**580** C6 Super Polaris* **IN STOCK**
C80 Refractor* ....**545** C80 Super Polaris*.....**619**
C102* .... **IN STOCK** C102 Super Polaris*....**899**
Call for Low Prices on Celestron C-11 and C-14 Telescopes
SPECIAL: 3" SOLAR FILTER for C-8's **119.95**
First Scope 80 w/Tripod & Alt-Azimuth Mt. **395**
Comet Catcher*F3.64 Compact Size ....**CALL**
C90 Spotting Scope ..**329** 60mm 15x60 RC Scope . **215**

Cometron Telescopes by Celestron

Comet Watcher	**99**	Cometron 40	**79**	Sky Watcher	**199**
Cometron 60 White	**150**	Sky Scanner	**249**	Deluxe 60	**219**
Comet Catcher JR	**219**	Equatorial Refract	**295**	CO114 Reflector	**379**

GIANT BINOCULARS* Complete w/Case and Tripod Adapter

11 x 80	**225.00**	20 x 80	**235.00**	30 x 80	**240.00**

Deluxe 20 x 80 w/Top Quality Optics **360.00**

"ALL ITEMS ARE COMPLETE WITH ALL ACCESSORIES AS SUPPLIED BY MANUFACTURER"

FOR TECHNICAL INFORMATION PLEASE CALL (212) 695-0697

ZEISS BINOCULARS

30x60 B/GAT*	**CALL**	Mini Binoc 10x25 BCF	**207.95**	Mini Binoc 8x20 B	**179.95**
Dialyt 8x30 B/GA IF	**324.95**	Dialyt 8x30 B/GA CF	**389.95**	Dialyt 8x30 B/CF	**388.95**
Dialyt 10x40 B/CF	**464.95**	Dialyt 10x40 B/GA CF	**469.95**	7x50 B/GAT*	**509.95**

NIKON BINOCULARS

9x30 CF HP	**189**	Spotting Scope	**209**	7x50 IF ASTRO	**389**
12x30 CF HP	**207**	ED Spotting Scope	**395**	7x50 CF HP	**375**
12x40 CF HP	**205**	Photo Attmnt for SS	**139**	7x50 IF Rubber	**217**
8x30 IF Rubber	**174**	Additional Eyepieces F/SS		7x50 Rbbr w/Scale	**264**
7x35 E CF wide	**128**	15X .... **49** 30X **49**		10x70 IF Wide	**379**
8x30 E CF Wide	**149**	40X **48** 60XF/ED			**50**
10x35 E CF Wide	**168**	Compact Binoculars			**CALL**

Minolta, Steiner, Leitz, Optolyth .... **IN STOCK**

PHOTOGRAPHIC OUTFITS-FOR ALL TELESCOPES

- **BASIC KIT** • 35mm Reflex Camera • "T" Mount • Wide Strap........................... **99.95**
- **ADVANCED KIT** • 35mm Reflex Camera • "T" Mount • Wide Strap • Deluxe Tripod.................... **129.95**
- with 50/1.7 Lens Add............................ **24.95**
- 50/1.7 Lens Add .. **24.95** • 35mm or 135mm . **19.95**

KODAK PROJECTORS & ACCESSORIES

4200	**137.95**	5200	**233.95**	140 Slide Tray	**5.75**	**80 Slide Tray**	**4.50**
4400	**168.95**	5400	**CALL**	Ektagraphic Tray			**6.95**
4600	**202.95**	5600	**294.95**	FHS Bulb	**16.95**	ELH	**12.50**
102mm f/2			**20.95**	Projector Case			**18.45**
Zoom Lens			**47.95**	25' ext. Remote cor			**11.95**
Stack Loader			**21.95**	40x40 Proj. Screen			**19.95**

TELESCOPE ACCESSORIES

Orthoscopic Oculars .96"	**36**	Rich Field Adapter 1¼"	**130**
Kellner Oculars .96"	**31**	T-C Video Adapter	**29**
Zoom 7-20mm Deluxe .96"	**89**	Expanding Bushing .96"-1¼"	**21**
Orthoscopic Oculars 1¼"	**44**	8x50 Rt Angle/St Fndrscope	**119**
Plossl Oculars 1¼"	**CALL**	2" Star Diagonal	**200**
Erfle Oculars 1¼"	**52**	Deluxe Latitude Adj. F/C90&C8	**47**
.96" Barlow 2x 2.5x & 3x	**32**	D-C Inverter	**95**
1¼" Barlow 2x	**32**	Multiple Ocular Holder 1¼"	**105**
1¼" Deluxe Barlow	**IN STOCK**	Off Axis Guider Body	**72**
.96" Eyepiece Filter Set	**50**	Off Axis Guider System	**150**
1¼" Eyepiece Filter Set	**52**	1¼" Terrestrial Eyepiece	**45**
1¼" Polarizing Filter Set	**56**	All Piggy Back Mounts	**38**
LRP #4 1¼" Nebula Filter	**63**	Solar Filter For C90	**125**
Skylight Filter #2	**35**	Meade Shade for Spot. Scope	**40**
Deluxe Tele Compressor	**105**	Meade .96" S.S. Conv. Kit	**79**
Solar Filters	**IN STOCK**	Meade 1¼" S.S. Conv. Kit	**99**

Meade Model 6600 Deep Space System

Meade Model 6600 6" f/5 Reflecting Telescope. A large-aperture telescope for the serious observer. American-made optics of Pyrex glass, polished to the most exacting specifications. Includes the Meade Professional Series equatorial mount, for precise astronomical tracking.
Accessorites include 2 eyepieces, 6x30mm viewfinder, slow motion controls.

Includes:
-Quartz Motor Drive Systems
-Polar Alignment Finder Scope
-2X Barlow Lens
-Sky Map

799.00
SAVE OVER $100.00

★★ **Latest 52 Page Celestron Catalog** ★★
The Guide To Telescope & Binoculars
$3.00 Post Paid/FREE with Order

Some telescopes may have limited availability.

New York Camera

131 W. 35th St. New York City, N.Y. 10001

212-564-4398 Telex 971877
800-223-6119 Sun 10-5
OPPOSITE MACY'S Mon-Fri 9-7

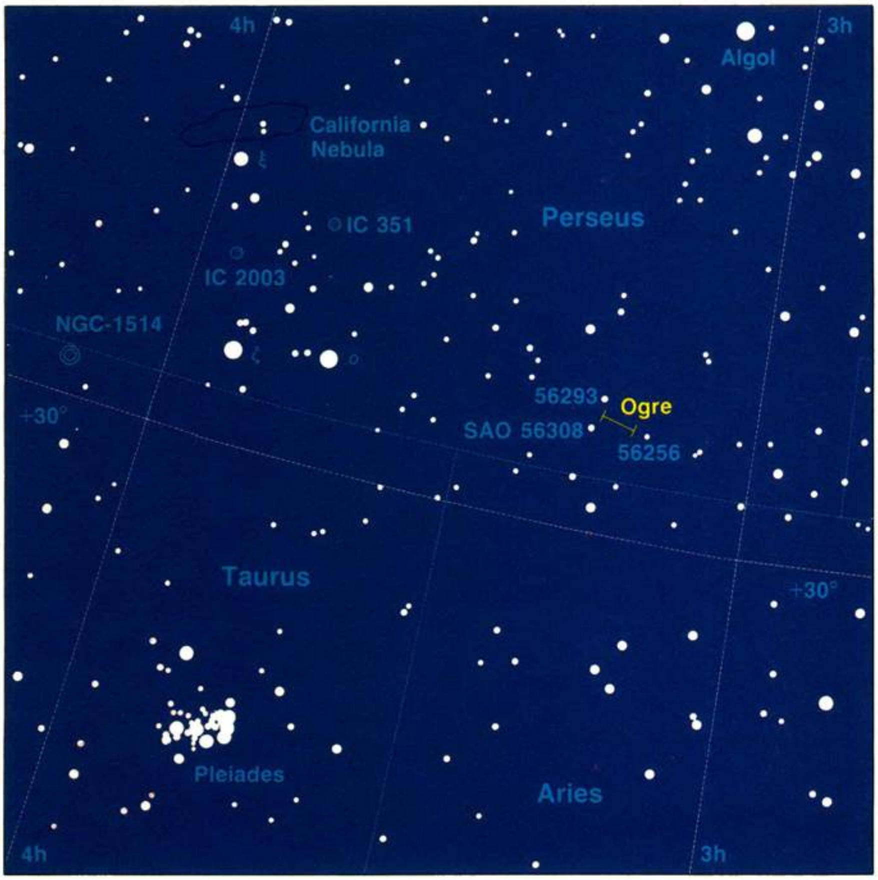
SEND CERTIFIED CHECK OR MONEY ORDER FOR IMMEDIATE SHIPMENTS. PLEASE ALLOW 30 DAYS FOR BANK CLEARANCE ON PERSONAL CHECKS. SHIPPING AND HANDLING NONREFUNDABLE. NOT RESPONSIBLE FOR TYPOGRAPHICAL ERRORS. SOME PRICES MAY REFLECT REBATE. OUR ONLY LOCATION 131 W 35 ST OPPOSITE MACY'S. MASTERCARD, VISA. PRICES GOOD UNTIL 3RD OF MONTH

ORDERS SHIPPED BY UPS WITHIN 24 HOURS. U.S. [illegible] warranty [illegible]. [illegible] AP [illegible]

Chasing the Ogre

Gazer's Gazette

by Bill Katz



The strangest thing happened a year ago last summer. During August 1984, Bruce Waters, Kai Millyard, and I — a group of enthusiastic Canadian meteor observers — observed three bright flashes of light near the same spot in the sky. We cautiously contacted other meteor observers, believing that the mysterious flashes might have been "point meteors." What else could bright spots of light in the sky be, anyway, but meteors coincidentally heading straight toward us?

On October 18th, however, I received a letter from Mark Zalcik, an expert meteor observer, who thought the flashes could *not* have been caused by point meteors. He suggested that some sort of star might be repeatedly but irregularly outbursting in a nova-like fashion. That same night, Zalcik went out and looked at the suspected position in the sky and he, too, saw a flash.

Suddenly our little group of observers had a giant-sized mystery on our hands. We had to talk to someone else — a professional astronomer. Ken Tapping of the Herzberg Institute for Astrophysics kindly talked to us about it and suggested an unusual possible answer: the flashes might be coming from a gamma-ray burster, an as-yet unexplained star that periodically throws off immense amounts of energy for a duration of several seconds. After hearing this, we nicknamed the object "the Ogre," which stands for Optical Gamma Ray Emitter, and decided that no matter how long it would take to find, we'd chase it.

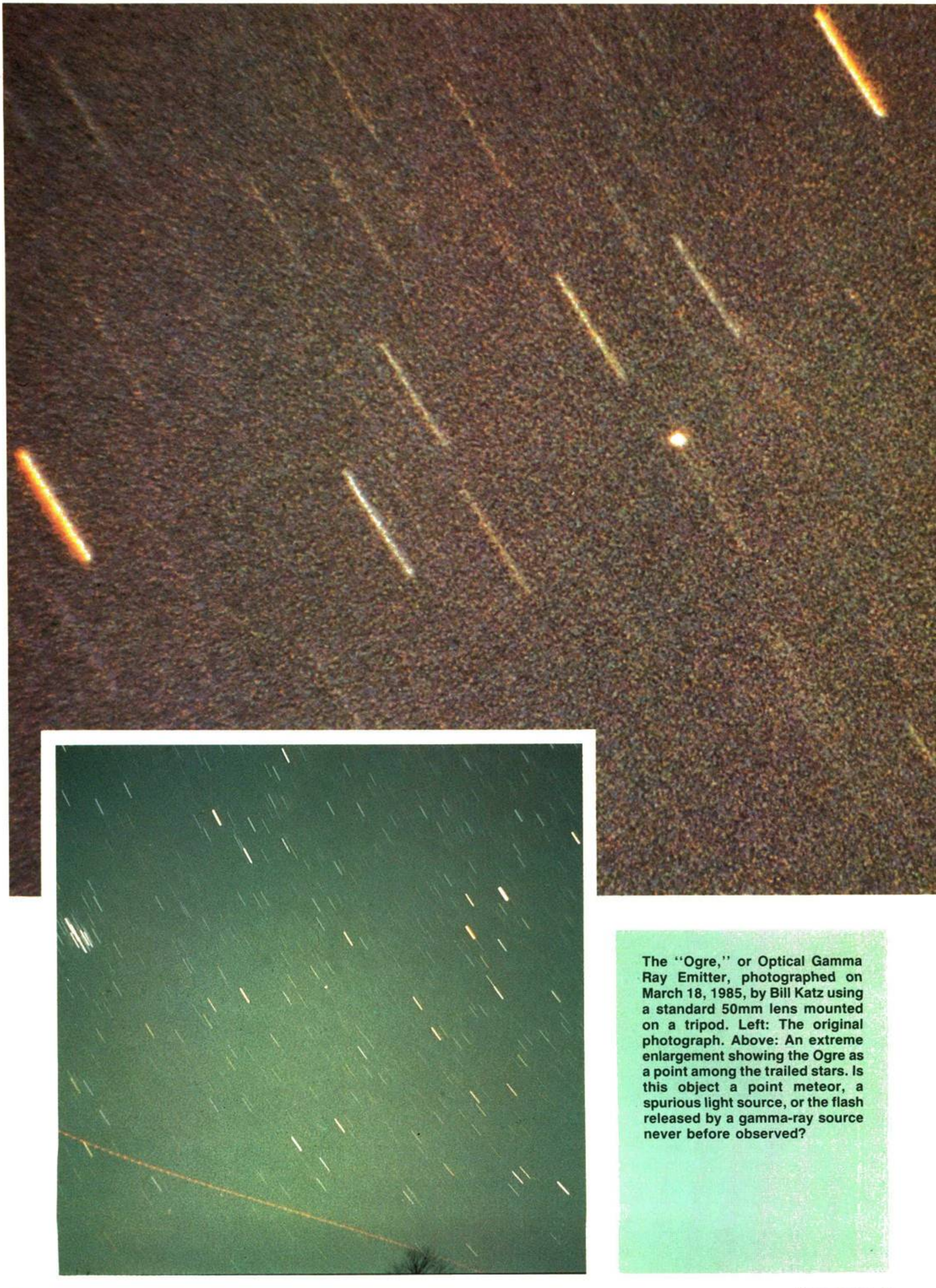
In talking to other professionals, we found that practically no one would take us seriously without some hard evidence. Despite the fact that we'd seen the flash 21 times, we lacked "photographic evidence." So we set out to photograph it for three reasons: to establish that the object really existed, to record its visual appearance, and to determine its position more accurately. On March 18, 1985 we set up a camera loaded with color film, aimed it at the area in the sky where we thought the Ogre lurked, and started an exposure.

None of us could believe our eyes when, at 9:42 p.m., the brightest flash the Ogre had yet produced went off and was recorded for posterity on our film frame. I visually estimated the flash at −1 magnitude. It was yellowish in color and lasted about one-fourth second. The photograph, reproduced here, corroborates these details.

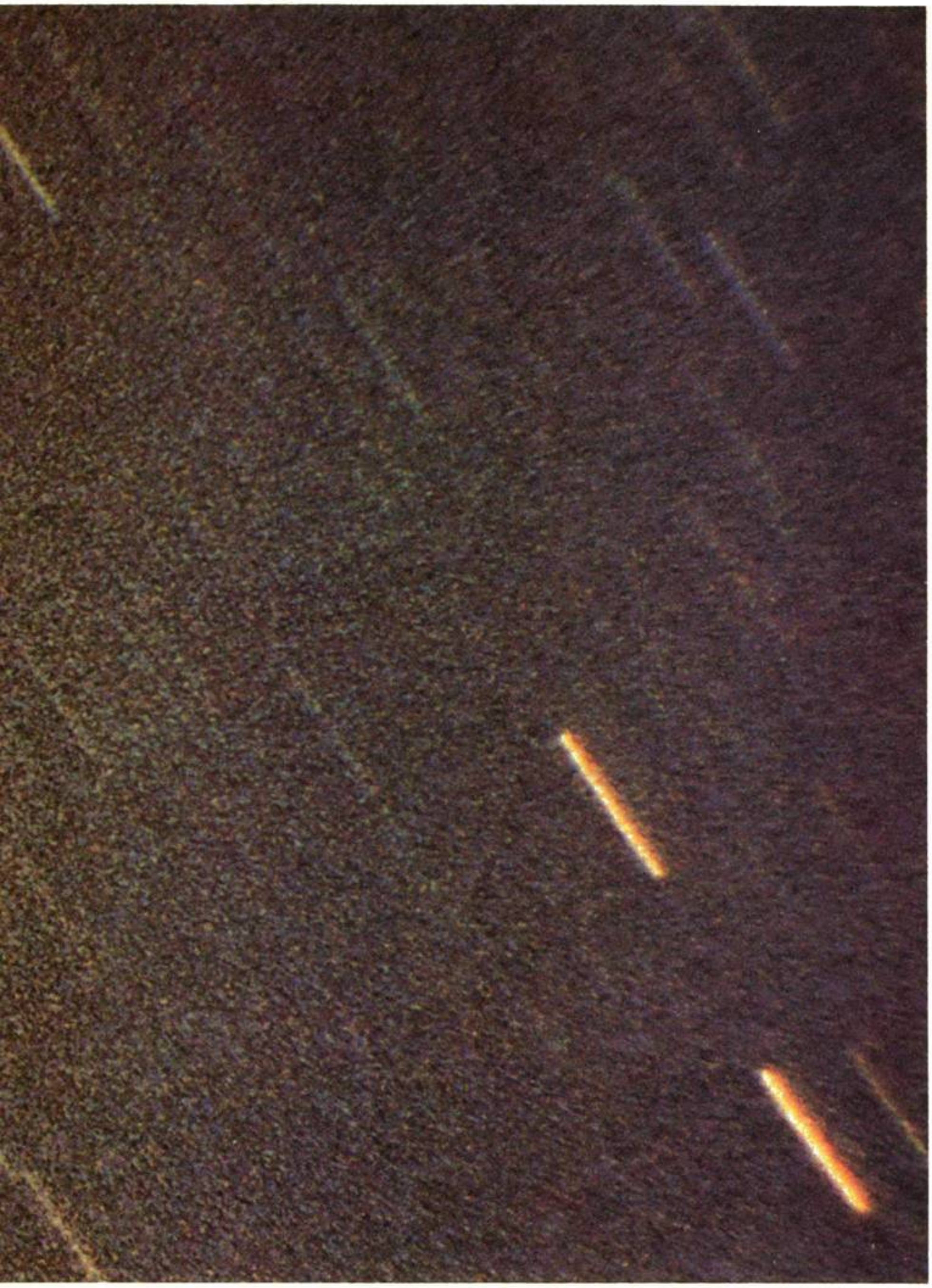
Even though we had a photograph, the skepticism didn't vanish. Instead, it became even worse. The only other evidence of optical light flashes from gamma-ray bursters exists on old sky survey plates made long ago at professional observatories. From these plates, astronomers had calculated that gamma-ray bursters flash optically about once a year. Could astronomers have been missing significant numbers of optical flashes from gamma-ray bursters all this time? The mystery continued.

Our group's six-month long quest to verify what we were seeing has been both trying and exciting, frustrating and rewarding. We learned a lot about various things: observing, possible new types of astronomical objects, and how to go about recording such phenomena. From our experience, we've cooked up some observing advice if you should decide to chase the Ogre yourself.

The most difficult part of observing the Ogre is determining its exact location. This is complicated because the eye has a natural tendency to move toward something with a known position (i.e., a star) after seeing a momentary flash. For some time, this led us to believe the Ogre was closer to the star SAO 75871 in Perseus than it actually is. The only way to



The "Ogre," or Optical Gamma Ray Emitter, photographed on March 18, 1985, by Bill Katz using a standard 50mm lens mounted on a tripod. Left: The original photograph. Above: An extreme enlargement showing the Ogre as a point among the trailed stars. Is this object a point meteor, a spurious light source, or the flash released by a gamma-ray source never before observed?



overcome this tendency is to make a mental map of the Ogre's position in relation to other bright stars that surround it.

The brightest stars in the vicinity of the Ogre are: Eta (η) Tauri (in the Pleiades cluster), Zeta (ζ) Persei, and Algol (Beta [β] Persei). The Ogre lies west of Zeta Per, roughly midway on a line drawn between the Pleiades and Algol. A closer approximate position based on analyzing the photograph places it inside the triangle formed by the bright stars SAO 56293 (a 6.3 magnitude double star), SAO 56308 (a 6.1 magnitude type G8 star), and SAO 56256 (an 8.0 magnitude type G5 star). If the Ogre exists, this is where it lurks.

If you attempt to find the Ogre, beware of several potential problems that might occur. First, it'll take immense patience for you to come up with anything. Don't be discouraged if you go out for a good many hours and see nothing; the momentary flash of the Ogre happens so quickly and infrequently that you should consider yourself lucky if you see it. Second, beware of poor seeing. If you spot fourth-magnitude stars "twinkling" on and off, don't try to observe the Ogre; you may be seeing a faint star popping in and out of the murk, leading to a false observation. Third, familiarize yourself with the area — the stars, the nebulae, etc. (See the map on page 99.) This will allow you to recognize key stars in the area and prevent you from potentially confusing them with the Ogre.

False flashes, real or imagined spots of light not attributable to the Ogre itself, can and do happen. They appear and seem very real at the time. Eye fatigue is one cause of this, so don't try observing unless your eyes are well rested. To further confuse things, flashes can be caused by other, real sources. Point meteors, bursts of light caused by a meteor coming straight toward you, happen only near the radiants of meteor showers. During my monitoring of the Ogre, I saw a Taurid point meteor but quickly dismissed it as such because of its position near the Taurid radiant. Also beware of flashes from planes and satellites, which can be visible momentarily if, say, a satellite is tumbling or a plane is tilted at a weird angle.

If you do see a flash, note the following information about it: position, brightness in relation to nearby stars, any change in brightness as the flash occurs, duration of the flash, its color, your observing location and time, sky conditions, and the details of how you saw it. These crucial bits of information can help determine whether you have spotted the Ogre or something else. I am most interested in receiving reports on the Ogre, which can be sent to the address below.

While more observations of the Ogre are needed to determine its pattern of behavior, the following information has been confirmed by a number of observations and may help you spot the Ogre: the flashes last from about one-sixth to one second, with the brighter flashes being the shortest; bright flashes are usually described as white or bluish-white in color, while dim flashes are often orange or yellowish; the flashes characteristically rise quickly to maximum brightness and take a little longer to dim out. Ogre flashes seem to occur at most about once every four days, but sometimes the flashes repeat themselves once every few hours or even once every few minutes.

Photographing the Ogre is easier than trying to observe it. Simply set up a camera aimed at the Ogre's approximate position and expose the film, either guided or unguided, for 15 minutes to an hour. After you develop the film frames, you can examine them for points of light in the right place. As an example of what the Ogre looks like in an unguided shot, see the photo at left.

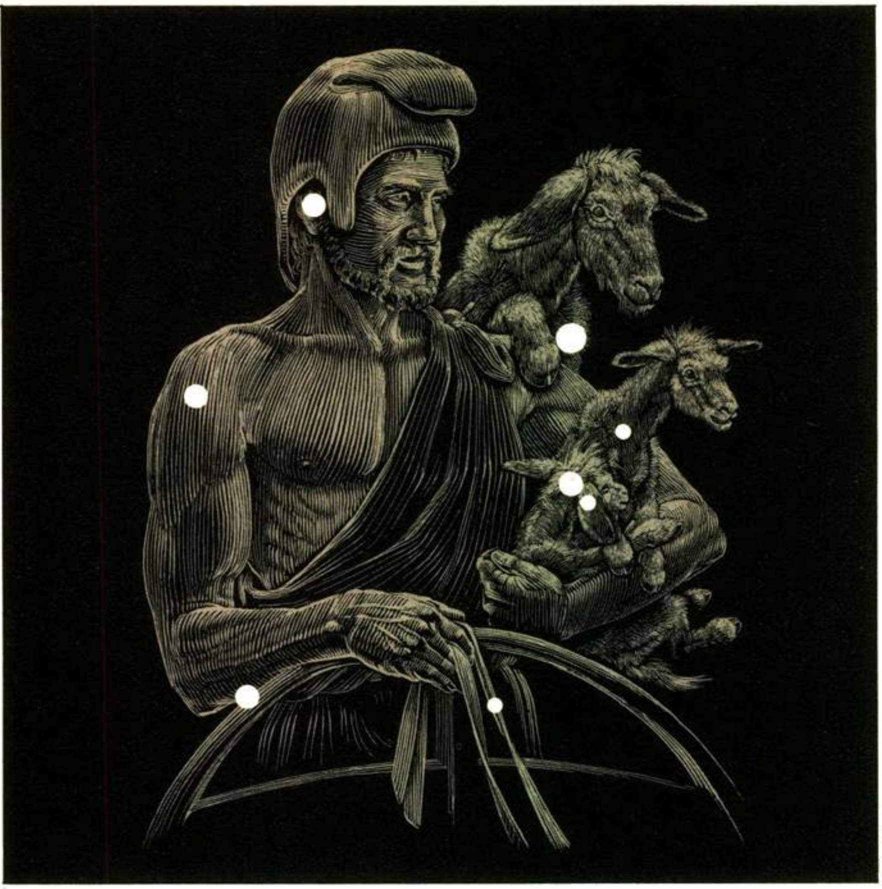
Even now, many months after the initial sightings of this strange flash of light, the story of the Ogre remains wrapped in uncertainty. Is the Ogre indeed a gamma-ray burster that occasionally flares to phenomenal brightness, an unidentifiable mystery, or a figment of our imaginations combined with an unfortunate defect on the film frame we claim confirms our story? The only way to tell for sure, fellow observers, is to gather more sightings and photographs of this strange object.

Bill Katz is a long-time meteor observer and photographer. Send Ogre sightings to: 43-02 223rd St., Bayside, NY 11361.

Above left: M-37 is one of the brightest, richest open clusters in the sky. Photo by David Healy. Below left: The faint emission nebula IC 405, called the Flaming Star Nebula, is visible in large backyard telescopes as a ghostly grey smear of light. Photo by Jack Newton. Top: The diminutive nebula NGC-1931 appears as a round ball of fuzzy light, much like an elliptical galaxy. Photo by Jack Newton. Above: M-36, lying inside the pentagon of Auriga, is an impressive collection of 60 stars. Photo by Jack Newton.

Auriga

Aur
Aurigae



Keith Ward

Known primarily for its brilliant star clusters — the finest being M-36, M-37, and M-38 — the pentagon-shaped constellation **Auriga** the Charioteer also contains several unusual nebulae owing to its position along a rich section of the winter Milky Way. By chance alignment, Auriga contains some unusual stars that lie relatively near us compared with the scattering of distant star clusters found in this part of the sky.

Lying about 5° west of Theta (θ) Aurigae is the open cluster **Messier 36** (NGC-1960), a large, bright grouping of at least 60 stars between magnitudes 9 and 14. This is one of the two Messier clusters lying within the pentagon of Auriga; M-38, detailed below, lies some 2.3° northwest. In a very low-power telescope both clusters are visible together. M-36's central core of bright stars measures only 10′ across, but it's bright enough to be spotted with small finder telescopes even under suburban skies.

With small telescopes, M-36 appears as a bright knot of two dozen stars in a circle spanning 15′. Most of the stars appear white or bluish-white, although a few hint at yellowish hues. Larger telescopes show progressively more stars in the cluster; a 16-inch reveals over 50 stars, most of them fainter than 11th magnitude, in a diameter of 15′. M-36 is fairly distant as bright clusters go. A study made at Lowell Observatory places it some 1.3 kiloparsecs away.

M-38 (NGC-1912) is larger and brighter than M-36 — bright enough to see in virtually any telescope or finder — but it contains fewer stars. Measuring 20′ across, some two-thirds the size of the Full Moon, M-38's stars are arranged in an irregular shape resembling an upside-down Greek letter π. The cluster contains many bright stars arranged in pairs. The brightest star in the cluster is an 8th-magnitude type G0-star, one much like our Sun but some 900 times brighter. This star is truly luminous; the Sun, if placed the same distance from Earth (1.3 kiloparsecs) would appear as a lowly magnitude 15.3 star.

The third of Messier's star clusters in Auriga is **M-37** (NGC-2099), lying just outside the pentagon several degrees southeast of the M-36/M-38 area. M-37, by far the richest of the three clusters, contains at least 150 stars brighter than 12th magnitude. Telescopes smaller than 2 inches show M-37 as a nebulous glow, but 3-inch or larger scopes resolve the outer parts of the cluster, revealing an enormous number of sparkling stars. Large backyard telescopes show nearly 200 stars, most of which are bluish-white or slightly yellow, in a field measuring 20′ across.

If you're observing with a 3-inch or larger telescope on a clear, dark night you should see a tiny smear of light just southwest of M-38. This is the diminutive cluster **NGC-1907**, a 5′ diameter collection of some 40 stars of magnitude 10 and fainter. Although unspectacular in backyard telescopes, NGC-1907 is a curious group in contrast to nearby M-38.

Midway between M-36 and the bright star Psi (ψ) Aurigae is a peanut-shaped emission nebula, **NGC-1931**. This object is one of the many relatively dim, small emission objects scattered along the galactic plane, a difficult object for observers equipped with small telescopes. An 8-inch scope under good skies shows the nebula as a double-lobed patch of greenish light some 3′ across with a few bright stars involved. A 16-inch scope more clearly reveals the nebula's outline, which resembles M-76 in Perseus.

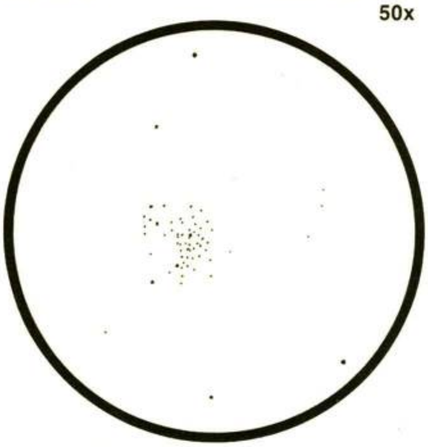
Due east of both M-36 and NGC-1931, past the star Psi (ψ) Aur, is the unusual star **AE Aurigae**. A bright O-type star, AE Aur normally shines at 6th magnitude but is capable of irregular and bizarre flares and drops in its light output. Its distance is about 550 parsecs, giving it an absolute luminosity of 900 Suns.

AE Aur is the illuminating source for **IC 405**, a large emission nebula called the Flaming Star Nebula. This faint, wispy cloud measures some 18′ across and contains structures similar to the Veil Nebula in Cygnus. Measurements of the nebula and star indicate that AE Aur is a rapidly-moving "runaway star" that originated in Orion along with the fast-paced stars Mu (μ) Columbae and 53 Arietis, both of which can be traced back to a common point of origin with AE Aur. The nebula IC 405 is a dust and gas cloud that happens, by sheer chance, to be illuminated by AE Aur at present. As time passes, AE will move through this cloud, leaving it dark once again.

For information on naked-eye sky viewing, including planets, constellations, and mythology, see **Eye on the Sky**.

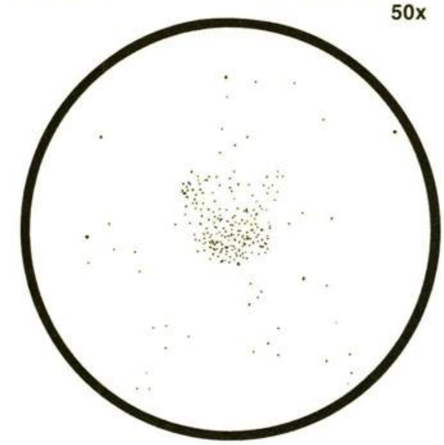
M-36

8-inch f/10 SCT
50x



M-37

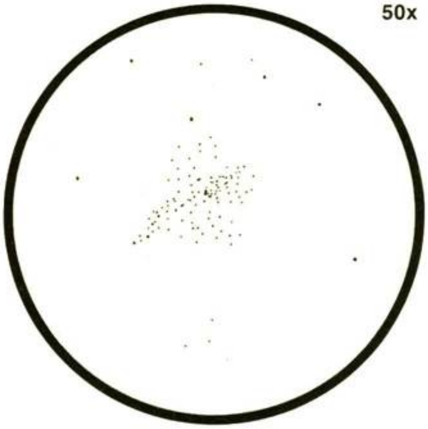
8-inch f/10 SCT
50x



Sketches by David J. Eicher

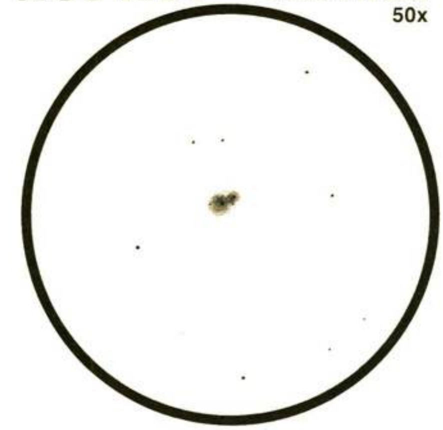
M-38

8-inch f/10 SCT
50x



NGC-1931

8-inch f/10 SCT
50x



Due south of M-36, about 3° east of the bright star Chi (χ) Aurigae, is the tiny, faint emission nebula **NGC-1985**. This object measures a mere 1′ across and appears in large telescopes as a round spot of hazy light. It certainly isn't impressive in most backyard telescopes, but it offers a challenge to those with a large telescope and dark sky.

On Auriga's border with Perseus is another large, bright star cluster designated **NGC-1664**. Containing 40 stars of magnitude 11 and fainter and measuring some 15′ across, NGC-1664 is visible in binoculars as a hazy peppering of faint light. A small refractor shows a large scattered group of two dozen stars encased in a faint haze; a 6-incher shows an area half the size of the Full Moon dotted with three dozen lights of various brightnesses and colors. NGC-1664 is a fine star cluster as viewed with virtually any instrument.

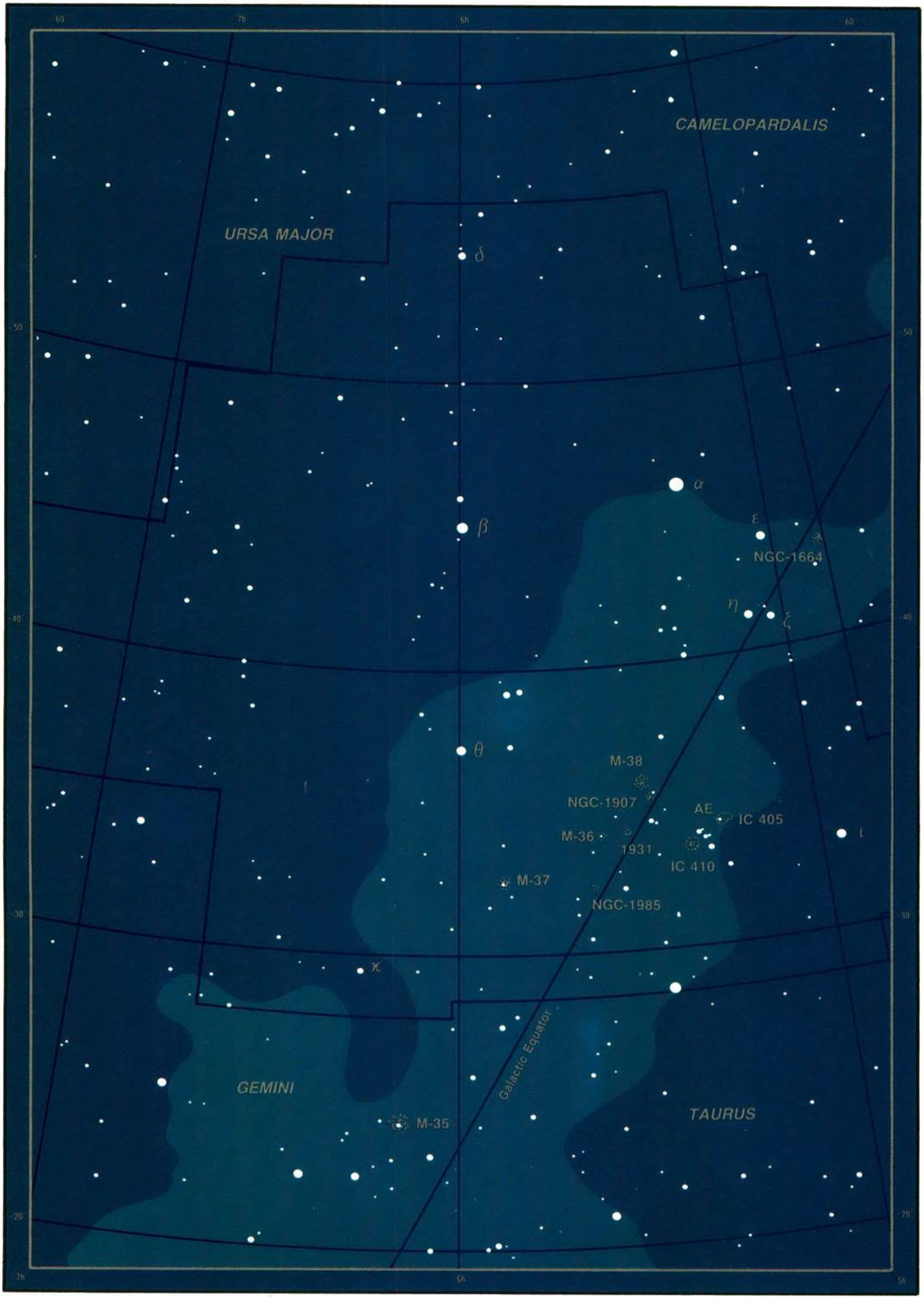
Another nice group of stars is **NGC-1893** which is located south of the midway point of a line drawn between M-36 and AE Aurigae. This group is irregularly shaped and contains 20 stars between 9th and 12th magnitude in an area spanning 12′. It is easily visible in most any telescope on a good night and quite bright in a telescope of 8-inches or more aperture. On very dark nights an 8-incher shows a faint haze pervading the cluster; in this case, it is not caused by unresolved faint stars but by the emission nebula **IC 410**. This faint cloud of gas measures a whopping 20′ across, but only the brightest few arc-minutes are visible in backyard telescopes.

The lone bright planetary nebula in Auriga lies just 3° north of Beta (β) Aur, one of the stars forming the pentagon. **IC 2149** is a bright disk of greenish light visible in any telescope, but it is so small that on nights of poor seeing it could be mistaken for a star. Its 10th-magnitude, 10″ disk requires high power and steady air to observe. Wait until a good night, find what appears to be a "fuzzy star" in the right area, and crank up the magnification to verify the disk structure. Large backyard scopes may show the 14th-magnitude central star.

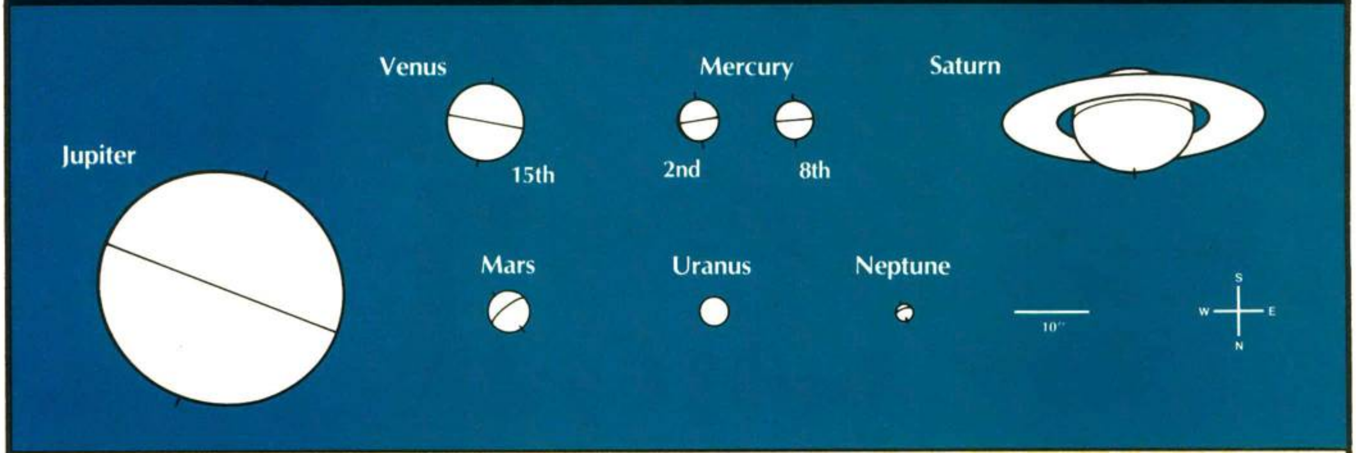
Auriga contains two bizarre variable stars — **Epsilon** (ε) **Aurigae** and **Zeta** (z) **Aurigae**. Epsilon lies 3° southwest of Capella (Alpha [α] Aurigae) and is normally a third-magnitude star. Once every 27 years, however, something extraordinary happens to the Epsilon Aur system: it undergoes an eclipse, dimming by almost a magnitude for nearly two years. What causes such a strange fading? The current model is that Epsilon Aur has a large, dark flat disk companion which passes in front of it every 27 years. The next eclipse should start in January, 2010. Zeta, found 2¾° south of Epsilon, is an eclipsing variable star made up of a giant K4 star and a small B7 main sequence star. Once every two years, the magnitude 3.8 star undergoes an eclipse and fades by a tenth of one magnitude for several weeks.

Object	M#	Type	R.A. (2000)	Dec.	Mag.	Size/Sep./Per.
NGC-1664		⊙	4h 51.1m	+43°42′	7.6	18′
Epsilon (ε		EV	5h 02.0m	+43°49′	2.9↔3.8	9892d
Zeta (ζ)		EV	5h 02.5m	+41°05′	3.7↔4.0	972d
IC 405		☐E	5h 16.2m	+34°16′	—	30′x19′
AE		IV	5h 16.3m	+34°19′	5.8↔6.1	irr.
IC 410		☐E	5h 22.6m	+33°31′	—	40′x30′
NGC-1893		⊙	5h 22.7m	+33°24′	7.5	11′
NGC-1907		⊙	5h 28.0m	+35°19′	8.2	7′
NGC-1912	M-38	⊙	5h 28.7m	+35°50′	6.4	21′
NGC-1931		☐E	5h 31.4m	+34°15′	—	3′
NGC-1960	M-36	⊙	5h 36.1m	+34°08′	6.0	12′
NGC-1985		☐E	5h 37.3m	+32°00′	—	3′
NGC-2099	M-37	⊙	5h52.4m	+32°33′	5.6	24′
IC 2149		■	5h 56.3m	+46°07′	11.2p	8″

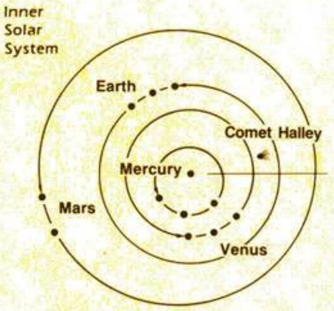
EV	*Eclipsing Variable*
IV	*Irregular Variable*
⊙	*Open Star Cluster*
■	*Planetary Nebula*
☐E	*Emission Nebula*

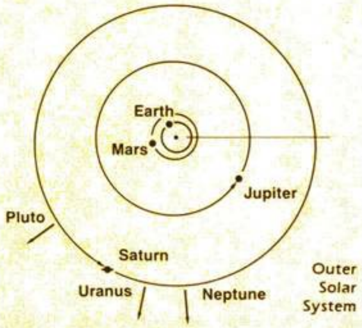

60
7h
6h
60
CAMELOPARDALIS
URSA MAJOR
δ
50
50
α
β
ε
NGC-1664
η
ζ
40
40
θ
M-38
NGC-1907
AE
IC 405
M-36
1931
ι
IC 410
M-37
NGC-1985
30
30
κ
Galactic Equator
GEMINI
M-35
TAURUS
20
20
7h
6h
5h

Planetary Data — January 1986


Venus
Mercury
Saturn
Jupiter
15th
2nd
8th
Mars
Uranus
Neptune
10″
S
W
E
N

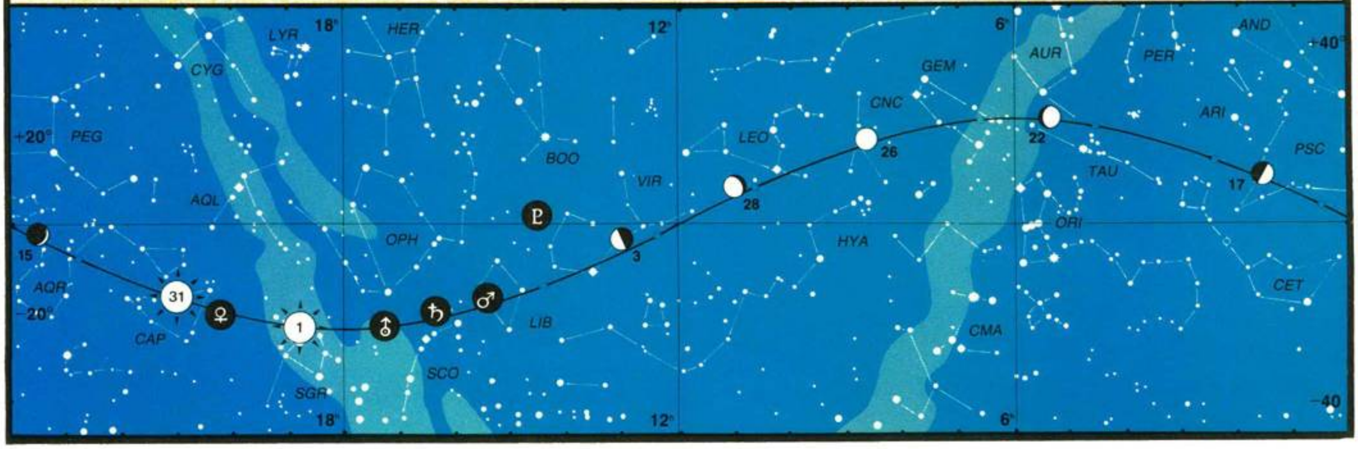
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Sun	Longitude: Heliocentric	Ecliptic	R.A. (2000.0)	Dec.
Sun		1	−26.8	32.6′	—	0.98	—	—	280°16.4′	18h 45.5m	−23°01.8′
		15	−26.8	32.6′	—	0.98	—	—	294°32.7′	19h 46.6m	−21°11.0′
		31	−26.8	32.5′	—	0.99	—	—	310°49.0′	20h 53.8m	−17°28.3′
Mercury	☿	1	−0.4	5.3″	88%	1.27	0.45	221°35.2′	263°06.4′	17h 29.9m	−22°58.8′
		15	−0.6	4.8″	96%	1.40	0.47	261°02.5′	284°07.8′	19h 01.9m	−23°57.7′
		31	−1.3	4.8″	100%	1.41	0.43	308°21.9′	310°17.8′	20h 53.2m	−19°40.7′
Venus	♀	1	−3.9	9.8″	100%	1.70	0.73	269°47.3′	276°00.9′	18h 26.2m	−23°38.3′
		15	−3.9	9.8″	100%	1.71	0.73	291°56.0′	293°37.7′	19h 42.5m	−22°12.2′
		31	−3.9	9.8″	100%	1.71	0.73	317°13.9′	313°44.0′	21h 06.3m	−17°55.0′
Mars	♂	10	1.4	5.2″	92%	1.81	1.63	193°26.0′	226°15.4′	14h 56.3m	−15°45.8′
		20	1.3	5.4″	92%	1.72	1.62	198°00.7′	232°17.6′	15h 20.5m	−17°27.8′
Jupiter	♃	15	−2.0	33.5″	100%	5.89	5.03	326°24.6′	321°33.4′	21h 36.7m	−15°05.3′
Saturn	♄	15	0.6	15.6″	100%	10.60	9.97	242°20.7′	246°44.0′	16h 20.9m	−19°38.5′
Uranus	⛢	15	5.7	3.5″	100%	19.93	19.12	258°37.9′	260°26.2′	17h 18.5m	−23°09.7′
Neptune	♆	15	8.0	2.2″	100%	31.17	30.25	273°27.8′	274°17.1′	18h 18.6m	−22°18.7′
Pluto	♇	15	13.8	0.1″	100%	29.93	29.74	215°15.1′	217°19.4′	14h 41.3m	1°38.2′


Inner
Solar
System
Earth
Comet Halley
Mercury
Mars
Venus


Earth
Mars
Jupiter
Pluto
Saturn
Uranus
Neptune
Outer
Solar
System

Moon Data

Last Quarter	January 3 at 19h47m
New Moon	January 10 at 12h22m
First Quarter	January 17 at 22h13m
Full Moon	January 26 at 00h31m
Last Quarter	February 2 at 4h41m
New Moon	February 9 at 00h55m
Perigee: Jan. 8 at 7h28m	363,304 km.
Apogee: Jan. 20 at 1h23m	404,719 km.


LYR
18h
HER
12h
6h
AUR
AND
+40°
CYG
GEM
PER
CNC
ARI
+20°
PEG
LEO
26
22
BOO
TAU
PSC
AQL
VIR
28
17
ORI
15
OPH
3
HYA
AQR
31
CET
−20°
1
LIB
CMA
CAP
SCO
SGR
−40
18h
12h
6h

Mercury

Starting from an elevation of 5° (45 minutes before sunrise) in the east-southeastern sky on January 1st, Mercury will sink day by day toward the horizon, vanishing into the morning twilight around the 10th; superior conjunction with the Sun comes on February 1st. At medium magnification in your telescope, Mercury will have a 5″ disk that looks like a featureless gibbous Moon.

Venus

Venus reaches superior conjunction with the Sun on January 19th and won't return to visibility until early March.

Earth

On January 2nd at 5h UT, Earth will be closest to the Sun: 0.98328 astronomical units, or 147.49 million kilometers.

Mars

Mars is an easily-found object in Libra. Shining pale orange at magnitude 1.3, the planet measures 5.3″ across on January 15th. At 16h24m UT on January 7th, Mars passes 39′ north of the dimmer component of the bright double star α Librae. Any low-power telescope will show the two together in the same field of view.

In January, Mars' northern hemisphere is tipped 24° toward the Sun, almost the greatest possible amount. (The martian summer solstice was in early December; the corresponding martian Earth month is July.) Between now and opposition on July 10th, observe Mars whenever you can. Over the months to come, you'll see the planet's disk slowly swell and grow brighter. In addition, the dusky markings on the planet, now barely visible, will become more pronounced and detailed.

Minor Planets

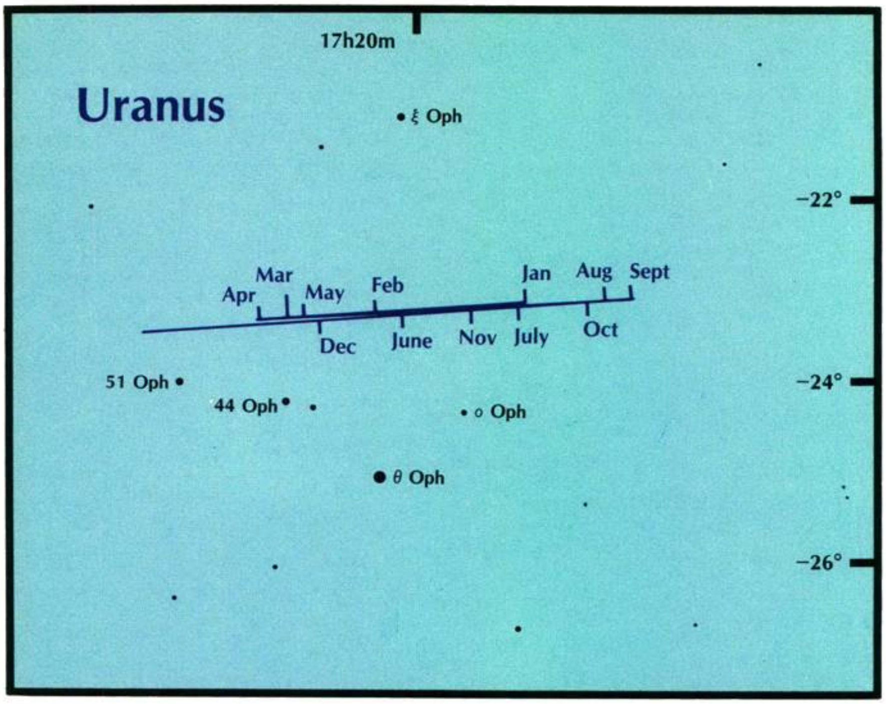
1 Ceres (magnitude 7.3) lies in the eastern part of Leo, between Denebola and θ Leonis. Its positions:

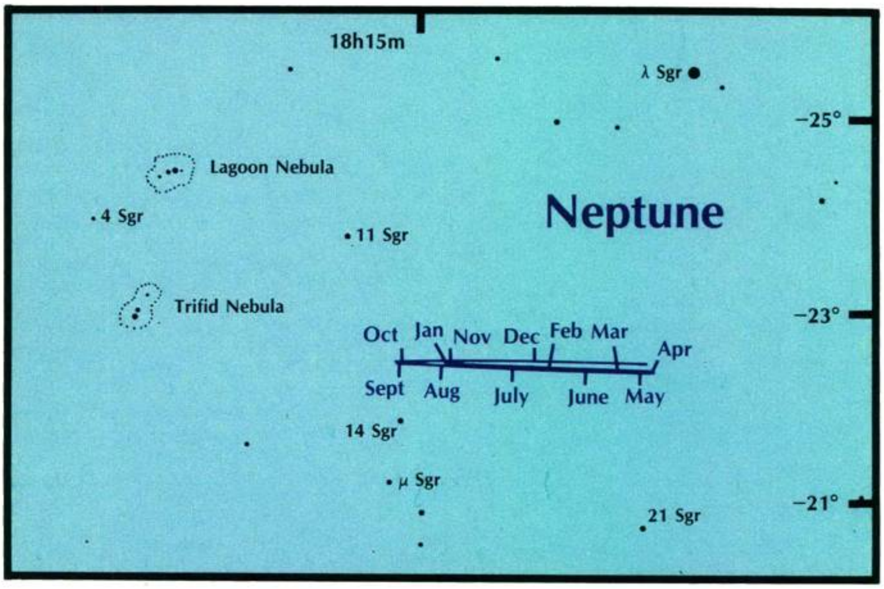
1st: 11h 24m 28s, 17° 15.2′
10th: 11h 27m 57s, 17° 52.8′
20th: 11h 29m 18s, 18° 50.6′
30th: 11h 27m 49s, 20° 02.2′

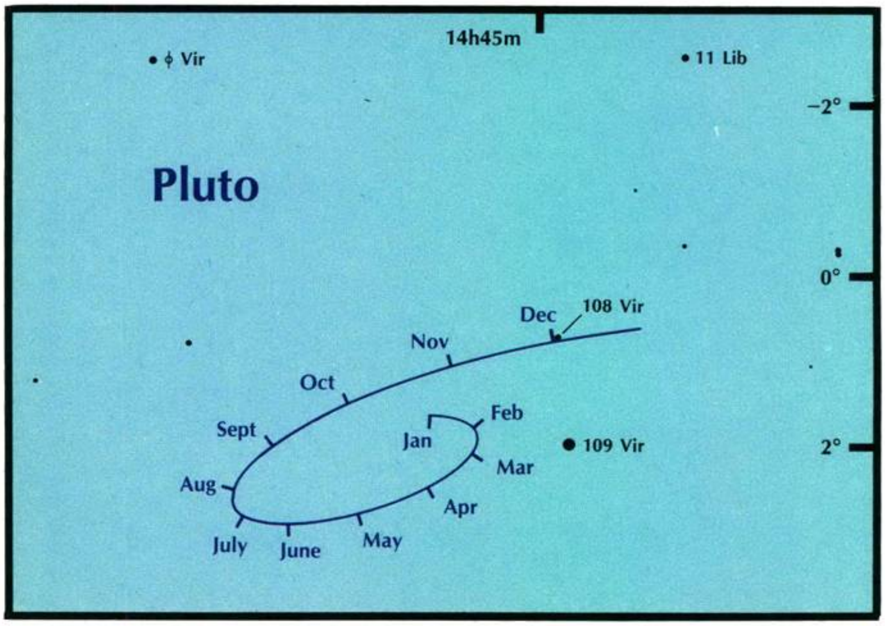
Ceres is transiting the meridian at about

Universal Time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times in The Backyard Astronomer are UT unless otherwise noted. To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska, 9; and Hawaii, 10. For example, if an event is to happen at 3h00m UT on February 2nd, then EST for the event is 10 p.m., February 1st. Likewise, 13h00m UT on March 5th becomes, in PST, 5 a.m, March 5th.


17h20m
Uranus
ξ Oph
−22°
Mar
Apr
May
Feb
Jan
Aug
Sept
Dec
June
Nov
July
Oct
51 Oph
44 Oph
o Oph
−24°
θ Oph
−26°


18h15m
λ Sgr
−25°
Lagoon Nebula
4 Sgr
11 Sgr
Neptune
Trifid Nebula
−23°
Oct
Jan
Nov
Dec
Feb
Mar
Apr
Sept
Aug
July
June
May
14 Sgr
μ Sgr
21 Sgr
−21°


14h45m
φ Vir
11 Lib
−2°
Pluto
0°
Dec
108 Vir
Nov
Oct
Sept
Feb
Jan
Mar
109 Vir
2°
Aug
Apr
July
June
May

Right: David Slutsky wins January's "Best Astro-Photo" award with his shot of M-27, the Dumbbell Nebula in Vulpecula. Slutsky used a 14-inch f/6 Newtonian and a 30-minute exposure on hypered Fuji 400 film that was developed as a negative in Unicolor's K-2 chemicals. Left: NGC-869 and NGC-884, better known as the Double Cluster in Perseus. Paul Roques took this picture with a 4-inch Schmidt camera and hypered 2415 film.

6 a.m. local time on the 15th.

2 Pallas (7.6) is moving northwestward in Columba. Its positions:

1st: 5h 54m 16s, −32° 30.2′
10th: 5h 47m 23s, −31° 12.4′
20th: 5h 41m 54s, −28° 59.6′
30th: 5h 39m 23s, −26° 08.4′

Pallas sets around 3 a.m. local time on the 15th.

3 Juno (11.5) is moving prograde in northeastern Libra. Its positions:

1st: 15h 56m 37s, −11° 03.5′
10th: 16h 07m 29s, −11° 14.5′
20th: 16h 18m 59s, −11° 19.3′
30th: 16h 29m 43s, −11° 16.1′

Juno rises about 5:30 a.m. local time on the 15th.

18 Melpomene (9.7) is at opposition on January 2nd in northern Monoceros. Its positions:

1st: 6h 51m 55s, 8° 50.5′
10th: 6h 44m 57s, 9° 45.9′
20th: 6h 35m 35s, 11° 03.5′
30th: 6h 28m 54s, 12° 24.0′

Melpomene is visible all night long this month.

To locate a minor planet, plot its dated positions lightly in pencil on a good star atlas (*Sky Atlas 2000.0*, for example) and sketch a smooth curve linking the points. Then observe the starfield at low magnification and photograph or plot by hand what you see. Check the field a night or two later; the faint "star" that has moved is it. (All minor planet coordinates are for the epoch 2000.0.)

Jupiter

Situated very low in the west as twilight deepens, Jupiter is about to vanish into the oncoming glow of the Sun. Although you can track it by eye into February, the planet won't make much of a target in your telescope's eyepiece because of its low altitude.

Saturn

Well up in the southeast as morning twilight begins, Saturn is a beautiful sight in any telescope. Observe the planet during full darkness and then keep watching it as dawn lightens the sky. At some point before sunrise, the contrast between planet and sky reaches a level that's ideal for spotting detail on Saturn's disk. And if the seeing's excellent, look for the elusive Encke's division that splits the outermost of the three main rings.

Uranus

As it emerges into the morning sky after conjunction, Uranus is moving eastward in the constellation Scorpius. On January 1st at 45 minutes before sunrise, Uranus is only 7° high. By the 15th it has risen to 14°, and by month's end it's a respectable 19°. Even so, finding a 6th-magnitude object that low in the dawn sky isn't easy. Try using the finder chart on page 107, but don't be surprised if you have to wait another month to observe Uranus easily.

Neptune

The same cautions that apply to Uranus go double for Neptune: by the end of January, Neptune will be only 13° high 45 minutes before sunrise. And since it's at 8th magnitude, the planet will be difficult to find in the star clutter of the Milky Way.

Meteors

January's one noteworthy meteor shower is the Quadrantid, which peaks around 12h UT on the 3rd. Unfortunately, the shower has an extremely brief maximum and its timing is bad this year: the peak comes when the Moon is at Last Quarter. In a good year, as many as 40 Quads per hour are visible, but this year's total will be far less.

Comet Halley

Halley's Comet is nosing southwestward through central Aquarius. Whether visible to the naked eye or not, the comet will be easy to locate in your telescope's finder. How far can you trace its tail? Can you see jets close to the bright nucleus — and can you see them change from day to day? Does the coma have any apparent structure in it? Observe, photograph, and sketch for all you're worth because this month is your last opportunity to see the comet before it reaches perihelion.

Elongations of Mercury & Venus — 1986

	Date	Altitude	Azimuth	Type & Extent of Elongation
Mercury	Feb. 28	9°	264°	East (evening sky), 18°
	Apr. 13	2°	96°	West (morning sky), 28°
	June 25	9°	290°	East (evening sky), 25°
	Aug. 11	1°	70°	West (morning sky), 19°
	Oct. 21	1°	241°	East (evening sky), 24°
	Nov. 30	10°	119°	West (morning sky), 20°
Venus	Aug. 27	9°	249°	East (evening sky), 46°

Altitudes and azimuths are given for 45 minutes after sunset (eastern elongations) or 45 minutes before sunrise (western elongations) as seen by an observer at 40° north latitude. In other latitudes the figures will vary slightly. North = azimuth 0° or 360°, east = 90°, south = 180°, and west = 270°.

the RENAISSANCE™

"... its ability to function effectively at low, medium, and high magnifications is outstanding."
— review in ASTRONOMY

CLEARLY BEST FOR HALLEY

Modern Photography tests revealed the highest contrast and resolution levels in its lens testing history, in its rave report on the Renaissance!

- –5 degree flat field, widest ever.
- –Dramatic 10X-286X power range.
- –Highest contrast, multi-coated optics.
- –Diffraction-limited resolution.
- –True 4" refractor.
- –Fast f/5.5, 550mm patented 4-element lens.
- –Advanced Renaissance equatorial mount.

With its polished solid brass tube, and new high tech equatorial mount, the Renaissance telephoto telescope is the most versatile and beautiful instrument available today.

Tele Vue eyepieces.
Clearly best for any telescope.

The most acclaimed eyepieces in the world. Patented designs for the sharpest, widest, highest contrast viewing ever. All telescopes including Celestron, Meade, Questar and imported scopes can be upgraded for the thrilling Tele Vue experience!

Plössls: 55mm (2"), 40mm, 32mm have widest fields possible —*essential for Halley.*

Other 50° field models—26mm, 21mm, 17mm, 13mm, 10.5mm, 7.4mm.

Barlows: 1.8X and 2.5X models enhance eyepiece performance.

Wide-Fields: 65° field and *sharp!* 40mm, 32mm (2"), 24mm, 19mm, 15mm (1¼").

Naglers: 82° field "spacewalk experience."—13mm, 11mm, 9mm, 7mm, 4.8mm.

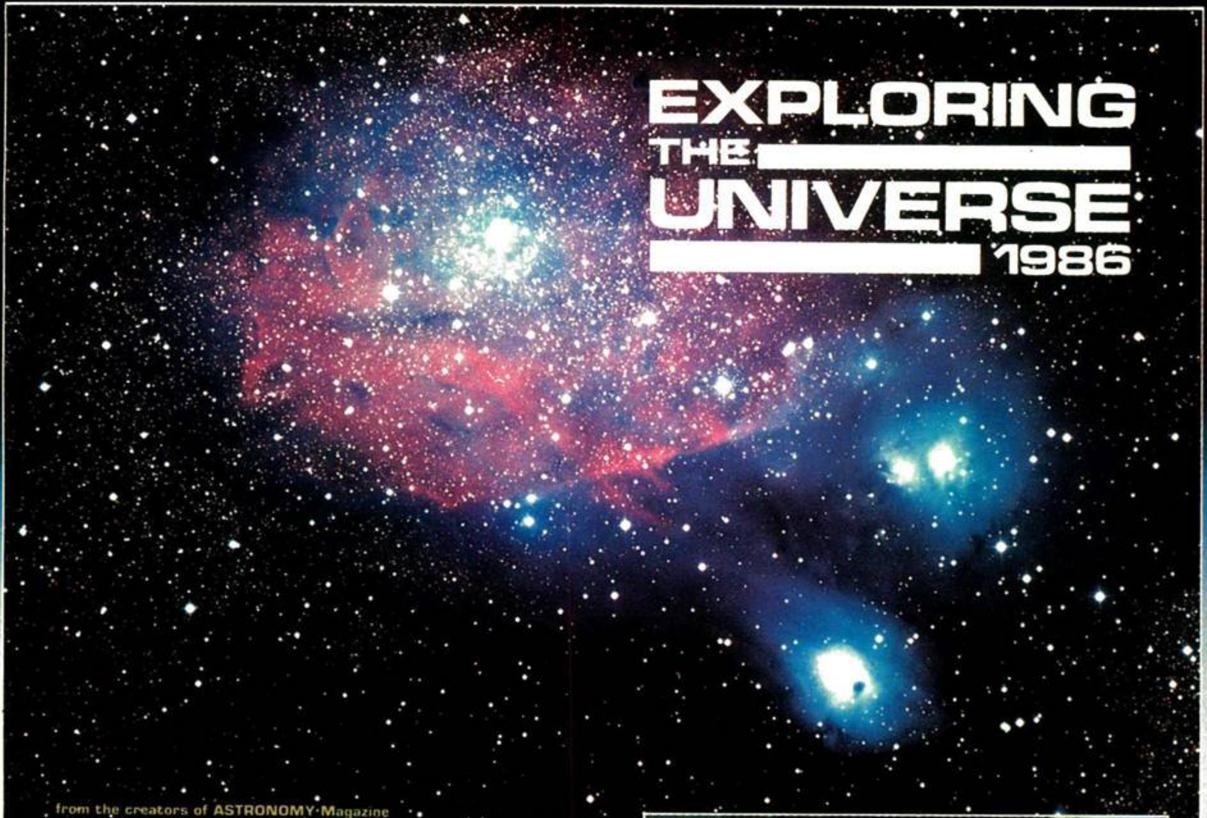
2" Star Diagonals with adapters: give rich field capability to C-8 and 2080 telescopes.

Visit your favorite dealer or send for free literature to discover the many superior details of Tele Vue products.

For Halley and Beyond

Tele Vue

20 Dexter Plaza, Pearl River, NY 10965
(914) 735-4044


EXPLORING
THE
UNIVERSE
1986
from the creators of ASTRONOMY Magazine
in cooperation with THE PLANETARY SOCIETY

Enjoy the wonders of space every day in the year!

Have you gazed awestruck across the lunar landscape at a beautiful blue and white marble hanging in space — Earth? Do you yearn to stop for a moment and admire the graceful curves of a distant spiral galaxy? Well, you can. Far more than a calendar for daily reference, EXPLORING THE UNIVERSE 1986 brings all the power and beauty of the universe to your wall. Thirteen magnificent 11'' x 14'' pictures transport you to the far corners of the universe — and each picture is ready for framing at the end of the month. For picture impact, reproduction fidelity, overall quality, and sheer magnificence, we think you'll agree that EXPLORING THE UNIVERSE 1986 is the most beautiful calendar you've ever seen!

- Full-color printing on heavy gloss stock
- Ample space to write appointments and special events
- Extra-heavy cover plastic laminated for durability
- 300 celestial events, anniversaries, and holidays listed
- Informative mini-essay accompanies every picture

$7.95 **includes shipping and handling**

Gift givers! Buy 3 and get a 4th FREE!

Please allow 4 to 6 weeks for delivery.

To order, use the ASTRONOMY order form bound into this magazine, or send to ASTRONOMY Order Dept., P.O. Box 92788, Milwaukee, WI 53202.

The telescope people look up to.

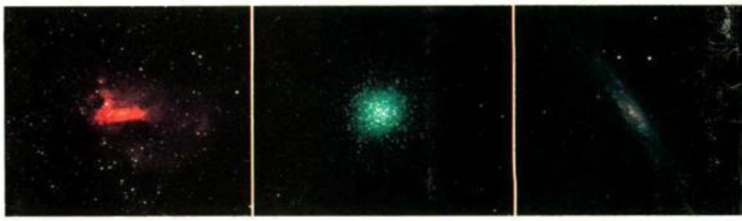
Is Celestron's Super C8 Plus an impossibly high standard to achieve? For other manufacturers apparently.

Making the world's finest optics requires a lot of nighttime sky. More than twenty year's worth, fifteen of which have been spent perfecting our C8. And when you spend that much time building, testing and refining a product, you set a very high standard indeed.

Consider our optics. They're engineered to a tolerance of 1/10 wave, about a millionth of an inch, for true "diffraction limited" optical performance. Our exclusive "matching" procedure puts corrector plate and mirrors in a special fixture to ensure precise optical alignment. Through laser testing we detect any minute flaws, then correct them.

These are slow processes, designed to meet our criteria for telescope performance, not sales performance.

Next, consider what you get in every Super C8 Plus. A telescope with 8-inch diameter, 2000mm focal length and F/10 focal ratio. In short, a telescope that provides the ideal balance between portability and large-diameter light-gathering ability.



C8 Astrophotographs: M-17, Omega Nebula; M-13, Globular Cluster; NGC-253.

Then there are the features that come with every Super C8 Plus: A stable Swing-through Fork Mount and an ultra-precise Byers Worm Gear Drive. Full setting circles and slow motion controls for both axes. And our Deluxe Latitude Adjuster.

An 8X50 polar alignment finderscope also comes standard, as do two oculars: a multicoated Plossl for wide field 77X magnification and a fully-coated Orthoscopic for 286X magnification.

There is a telescope, however, equal to the Super C8 Plus. Our own Super Polaris C8. It offers the same optics, the same performance. The Super Polaris Mount, which features a precise built-in polar alignment telescope, can be used with our optional Sky Sensor computer control system.

Now, if you'd rather look through a Super C8 Plus or SP-C8 than look up to one, focus on the Celestron dealer nearest you.

Just because some manufacturers can't raise their standards is no reason for you to lower yours.

CELESTRON®

Celestron International,
P.O. Box 3578, 2835 Columbia St.,
Torrance, CA 90503 (213) 328-9560
For more information and the name of the dealer nearest you, call Free 1-800-421-1526 (Mon.–Fri., 8–4:00 pm; Continental USA only). For a catalog, send $3.00 to Celestron International.